A STUDY OF RECENT FORAMINIFERA FROM THE SANDY BEACHES OF WESTERN INDIA

ABSTRACT

THESIS SUBMITTED TO THE ALIGARH MUSLIM UNIVERSITY
IN FULFILMENT OF THE REQUIREMENT FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY IN GEOLOGY

By

RAJIV NIGAM

M. Sc. (Lucknow), M. Phil. (Aligarh)

Department of Geology
Aligarh Muslim University, Aligarh

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ABSTRACT

The present work is the first documentation of the detailed study carried out on various aspects of Recent Foraminifera from sandy beaches of Western India. 13 well-exposed beaches from Bombay to Kanniyakumari dotting the West Coast of India were taken for the present study. The study reveals the presence of a fairly rich assemblage of Recent foraminifera.

The foraminiferal fauna consists of 114 species, including 4 new species. The assemblage contains representative of Miliolidae (32.45%); Elphididae (9.65%); Nubeculariidae and Rotaliidae (each 8.77%); Cibicidae (5.26%); Nonionidae (3.51%); Nodosariidae and Bolivinidae (each 4.39%), Textulariidae, Uvigerinidae, Globigerinidae, Eponididae (each 2.63%); Glabratellidae and Amphisteginidae (each 1.75%); Lituolidae, Trochamminidae, Glandulinidae, Buliminidae, Discorbidae, Epistomariidae, Nummulitidae, Globorotaliidae, caucasinidae and Anomalinidae (each 0.88%). The new species of foraminifera are: Quinqueloculina

hagni, Q. singhi, Triloculina qasimi, Caribeanella indica.

The following species are being reported for the first time from Indian waters: Spiroloculina rotunda, S. tricarinata, Quinquloculina bicarinata, Q. mediterranensis, Q. oblonga, Q. phoenica, Q. polygona, Q. rugosa, Q. aff. Q. viennensis, Miliolinella australis, M. oblonga, Lagena vulgaris, Bolivina laevigata, Ammonia indica, Cribroelphidium sp., Pararotalia minuta, Cibicides tenulus.

The foraminiferal assemblage of the beach fauna from the West Coast comprises almost entirely of benthonic species. The planktonic foraminifera are rare and only a few specimens were encountered, belonging to 4 species, viz., Globorotalia cultrata cultrata, Globigerina bulloides, Globigerinoides ruber and globoquadrina dutertrei. The ratio of planktonic benthonic species is 1: 28.75.

The study shows that Textulariina never exceeds 8.3% of the total foraminiferal number. Miliolina is also rare (0.28 to 17.75%) and fauna is mostly composed of Rotatiina (82.25 to 99.72%).

In the present study an attempt has been made to work out the variation of foraminiferal assemblage with latitude.

It is observed that total foraminiferal number (TFN) and total species number (TSN) decreases with the decrease in latitude.

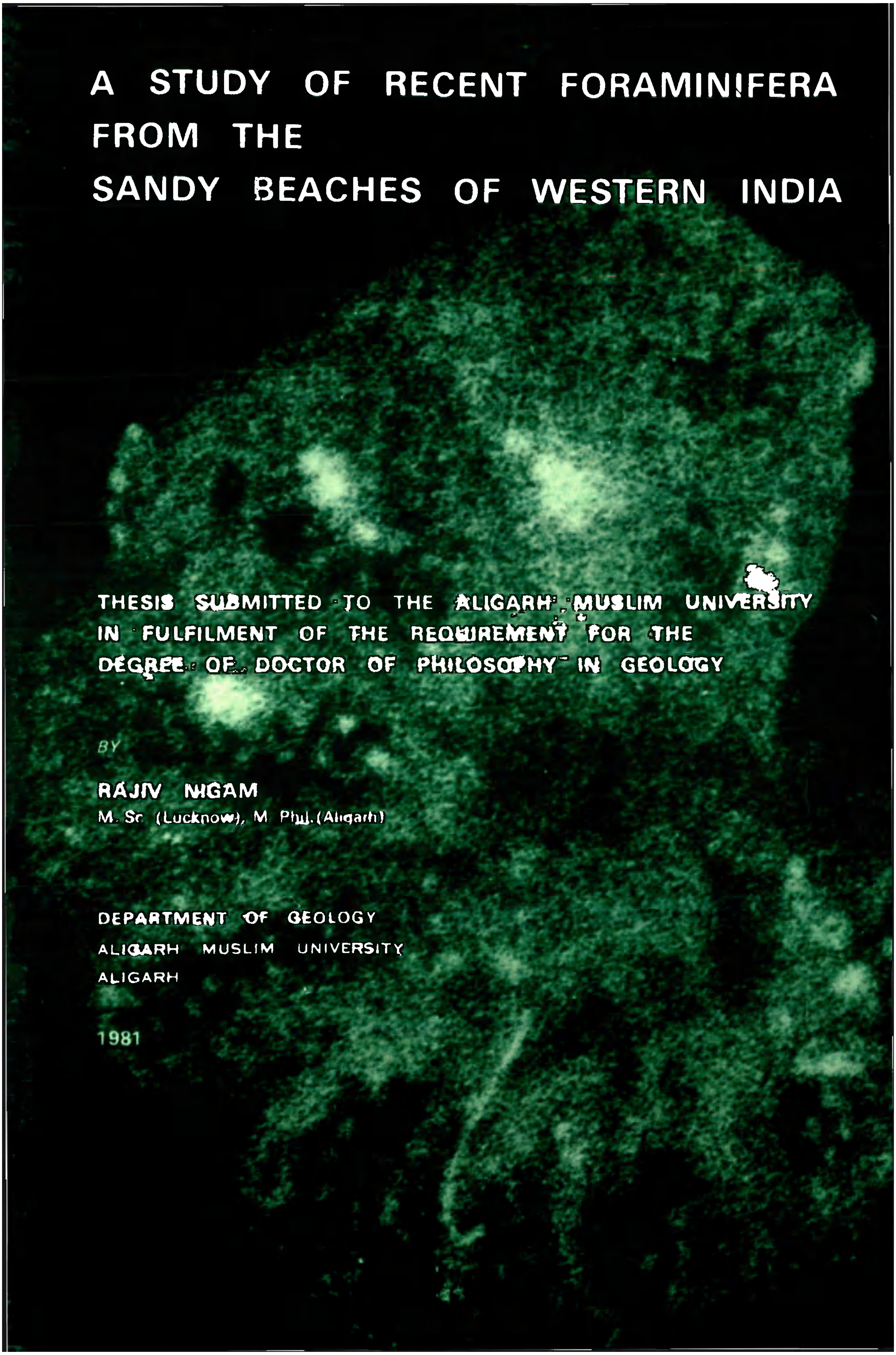
The presence of relict foraminifera (47.60% to 74.25%) has been recorded at certain beaches of the southern part of the West Coast. Possible source of these specimens is discussed in detail.

Being very sensitive to environment, foraminifers serve as excellent indicators of marine pollution. Foraminiferal fauna of Sangomukum beach (Trivandrum) shows corrosion on foraminiferal test due to high acidic (Ph 1.4 to 2.0) effluent discharged by Travancore Titanium Products Limited.

The distribution data of foraminifera obtained from the present study was compared with the published reports on foraminiferal fauna from the West and East Coasts of India. The comparison shows a remarkable difference in fauna from both the coasts of India.

A Q-mode cluster analysis technique was applied to distribution data of 76 species from 17 beaches

(13 from present study and 4 from earlier published reports). Out of these, 14 beaches are from the West Coast and 3 are from the East Coast of India. Results were represented in form of a dendrogram which leads to the conclusion that the West and East Coasts of India belong to two distinct faunal realms.



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DR. S. N. BHALLA
M.Sc., Ph.D., D.Sc.

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH 202001, INDIA

This is certify that Shri Rajiv Nigam has completed his research under my supervision for the degree of Doctor of Philosophy of Aligarh Muslim University. This work is an original contribution to our knowledge of the Recent foraminifera from sandy beaches of western India and has not been published anywhere.

He is allowed to submit the work for the Ph.D. degree of the Aligarh Muslim University, Aligarh.

S. N. Bhalla.
S. N. BHALLA 15/12/80
Supervisor

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE OF STUDY

The study of Recent foraminifera is most fascinating and significant from academic as well as applied point of view. In recent years, therefore, much emphasis is being laid on the studies of these micro-organisms all over the world.

The study of Recent foraminifera helps solving a variety of problems, eg., taxonomy, life cycles, ontogenetic developments, test structure and composition, etc., which are indeed of great value to foraminiferologists working on the various academic aspects of this branch of Geology.

It is a well-known fact that organisms live in perfect balance with environment. Evidently, many fossil organisms resemble their living counterparts in forms, composition, habits, etc. Foraminifera, like other groups of organism, are highly suseptible to environmental changes. Therefore, the ecological data obtained from the study of foraminifera in modern seas is of utmost significance in deducing the paleoecology of the sediments which contained their fossilized ancestors. Being very sensitive to environmental stress, they are now being increasingly used to carry out pollution studies along the coastal areas.

Inspite of their small size, foraminifera play significant role in oceanographic and paleoceanographic studies. Their distribution pattern provides a better understanding of sea level fluctuations, sub-marine topographic irregularities, migration of shore lines, shifting of substrates, water currents, sea-floor spreading and a host of other aspects. Lately, the thrust of oil exploration in India is on offshore regions, and recent finding of oil at Bombay High and nearby regions has encouraged oil geologists to search for oil in other offshore regions of the country. In this context, it is all the more necessary to study the Recent foraminifera from Indian coasts for a better understanding of fossil assemblages of these regions.

In view of the foregoing advantages of the study of Recent foraminifera, the author undertook a detailed study of foraminifera from the west coast of India. Unfortunately, offshore samples were not available and, therefore, present work had to be restricted to the sandy beaches dotting the western shore-line of the country, stretching from Bombay in the north to Kanniyakumari in the south.

In view of limited time, only the systematic part of the foraminiferal study, effects of pollution, latitudinal variations and affinities of foraminifera are the concern of the present study.

It is hoped that this modest beginning will pave the way for future workers on Recent foraminifera from the Indian coasts which is still in infancy in this country.

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CHAPTER 2

HISTORICAL RESUME

Bandy *et al.* (1972) summarised the work done on foraminifera from Indian Ocean and adjacent seas. A review of literature reveals that the Arabian sea in general and its portion adjacent to the west coast of India in particular, is rather neglected. Following is the list of foraminiferal studies carried out by earlier investigators along the west coast of India.

2.1 BEACH FAUNA

The work on foraminifera from west coast beaches commenced with Chaudhary and Biswas (1954) who worked on Juhu beach sand near Bombay and recorded 12 species of perforate foraminifera. These authors were followed by Bhatia (1956) who described and illustrated 46 species of foraminifera from Bhogat (Gujarat), Chaupatty and Juhu (Bombay) beaches. Later, Rocha and Ubaldo (1964 a,b) recorded 21 species from Baga (Goa), 7 species from Jampore (Damao) and 52 species from Div, Gogola and Simbor beaches. Jain and Jain and Bhatia (1978) reported 37 species of foraminifera from Mandvi beach (Kutch) and erected one new species *Pararotalia boltovoskoyi*. More recently, Bhalla and

Nigam (1979) obtained 36 species from Calangute beach sand, Goa.

2.2 NEARSHORE AND OFFSHORE FAUNA

Sastri (1963) prepared an annoted bibliography of foraminiferal studies from Indian waters.

2.2.1 Benthonic Foraminifera:

Important foraminiferal investigations started with Sethulekshmi Amma (1958) and Antony (1968). They studied mainly benthonic species and a few planktonic species of foraminifera from Kerala coast. Rao (1970,a,b; 1971,a) reported 84 species from 4 samples from Gulf of Cambay. He also studied Recent foraminifera from Saurashtra coast (Rao, 1971,b). Setty (1974) obtained 32 species of benthonic foraminifera from top of a core from Kerala coast. Zobel (1973) analysed some samples from Indian region. Rao (1974) described ecology of Mandovi and Zuari estuaries from Goa on the basis of benthonic foraminiferal assemblage. Seibold (1975) examined some samples from lagoon and cost off Cochin. An account of Recent foraminifera from polluted marine environment of Cola bay (Goa) was given by Setty (1976). A check-list of 64 benthonic foraminiferides has been recently reported by Nigam _et al_. (1979) from shelf region of Ratnagiri.

2.2.2 Planktonic foraminifera:

Planktonic foraminifera from the west coast of India are well documented as compared to benthonic foraminifera. Zobel (1971) studied planktonic foraminifera from Arabian sea and discussed ocean water masses. Setty (1972), Rao (1973) and Guptha (1973,b) also studied planktonic foraminifera from Kerala coast. Setty and Guptha (1972) recorded 15 species of planktonic foraminifera from bottom sediments of Karwar and Mangalore. Rao (1972) and Guptha (1975) studied '<u>INS Darshak</u>' samples from Bombay region for planktonic foraminiferal study.

All the reports on foraminiferal distribution are regional and no attempt has yet been made to study the Recent foraminiferal variation along the entire west coast of India. Also, its comparison to the east coast foraminiferal fauna and placement of the west coast assemblage to the known foramgeographical provinces has not been studied so far.

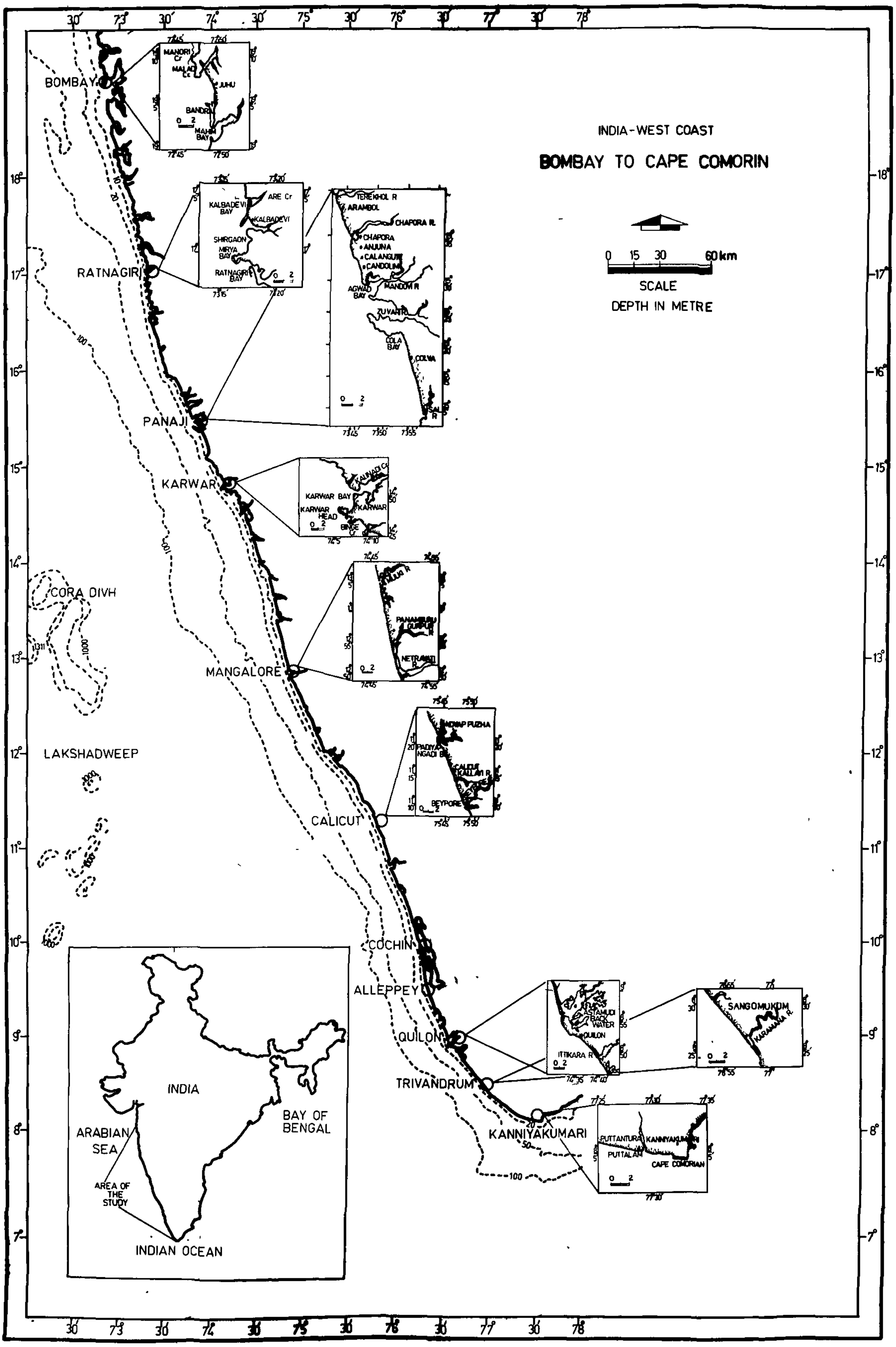


Fig.-1. STATION LOCATIONS MAP

CHAPTER 3

LOCATION, ENVIRONMENT AND METHOD

3.1 LOCATION

All the 13 beaches included in the present work are from the west coast of India, bordering the Arabian sea (Fig. 1). Since a beach is a long strip of sands, only coordinate for the middle point of each beach is given in Table 1.

3.2 ENVIRONMENT

Beach fauna reflects the near shore environment. Hence, to understand the distribution of foraminifera, knowledge of bathymetry, regional setting and hydrography of the shelf waters is necessary.

Ecological data for various environmental parameters have been taken from different sources (published papers, unpublished reports, and personal communications) and are summarised here.

3.2.1 Regional Setting

Beaches included in the present work are scattered all

TABLE 1: SHOWING LOCATIONS OF BEACHES STUDIED IN THE PRESENT WORK

S. No.	Name of beach	Latitude N	Longitude S
1.	Juhu	19°7'	72°54.5'
2.	Ratnagiri	17°3.5'	73°17'
3.	Arambol	15°36'30"	73°44'
4.	Chapora	15°34'5"	73°47'
5.	Anjuna	15°33'10"	73°47'
6.	Calangute	15°31'40"	73°47'
7.	Condolim	15°30'40"	73°47'
8.	Karwar	14°48'	74°75'
9.	Mangalore	12°56'	74°48'
10.	Calicut	11°16'	75°46'
11.	Quilon	8°52'	76°37.5'
12.	Sangomukum	8°28'	77°7.5'
13.	Kanniyakumari	8°3.5'	77°30'

along the west coast of India. The coast line is approximately straight and trends in NNW-SSE direction. According to Guha (1959) and Krishnan (1959), the remarkable straight alignment of the coast is due to faulting probably during Plio-Pliestocene times and then its subsequent submergence.

3.2.2 Physiography and Bathymetry

The shelf along the west coast has been divided and studied horizontally as well as vertically.

(a) Horizontal Classification

Horizontally, shelf may be divided into four different regions, namely, the shelf off Saurashtra; from Gulf of Cambay to Mangalore; Mangalore to Quilon; and Quilon to Kanniyakumari. The divisions are rather arbitrary and are based on differences in climatic conditions, shelf width and depth of shelf break, etc.

(i) Shelf off Saurashtra

It is characterised by hot and dry climate with little run off from land. It has a shelf width of about 120 km and a shelf break in the range of 130 to 152 m.

(ii) Shelf from Gulf of Cambay to Mangalore

This coast has a hot, wet, climate. The dominating climate factor is the south-west monsoon (June to September) during which the fresh-water discharge reaches its maximum extent, and the estuaries which are well mixed in the non-monsoon months (October to May) become stratified and also carry large amount of sediments. Two major rivers, the Narmada and Tapti, flow into the Gulf of Cambay and, in addition, a few small rivers, Shastri, Vashisti, Mandovi, Zuari, Kali, Netravati, etc., and numerous seasonal streams discharge into the several estuaries found along the coast. The shelf width off Bombay is about 280 km and off Mangalore about 80 km. The shelf break occurs between 90 and 140 m.

(iii) <u>Shelf from Mangalore to Quilon</u>

There is not much difference in the monsoonal conditions between this sector and the Bombay-Mangalore sector. But fresh-water run off is very low as there is no major river in this sector. Only a few small rivers, like Beypore and some nallahs or <u>puzas</u> are present. The important feature of this sector is the famous Cochin back-water and Vembanad lake. The shelf width of this sector is 80 km off Mangalore and 54 km off Quilon. The shelf break is between 70 to 120 m.

(iv) Shelf from Quilon to Kanniyakumari

In general, the climate of this region is monsoonal and wet. The main feature of this sector is mixing of waters from the Arabian sea and the Bay of Bengal at its southern end near Kanniyakumari. Sediments of this sector are coarse as compared to above sectors. Shelf width is from 54 to 97km, but the data about shelf break are not available.

(b) Vertical Classification

The shelf can further be divided vertically into the inner-shelf (0-60 m) and the outer shelf (60 m to the shelf break) zones. The topography and sediments of each of these zones, are very different. The inner shelf has smooth, featureless topography whereas the outer-shelf has topographic irregularities which range in relief from 1 to 10 m (Nair, 1975). These topographic irregularities consist of algal and oolitic ridges which were formed during the Holocene sea transgression (Nair, 1975). A prominent feature on the outer-shelf is the 50 fathom flat which, as the name indicates, is found at the depth of 90 m (Nair, 1971). This is the largest feature of its kind in the world (Shepard, 1963).

The sediments of the inner and outer shelfs are also markedly different. The inner shelf sediments are terrigenous silts and clays whereas outer shelf sediments are relict carbonate sands (Nair and Pylee, 1968).

3.2.3 Hydrography

3.2.3.1 Salinity

Salinity is one of the important factors controlling the distribution and ecology of Recent foraminifera. It is of great importance while dealing with their latitudinal variations.

Data regarding the distribution of salinity along the west coast is scattered in a number of research papers. Only a few attempts have been made to study the complete variation of salinity along the west coast of India (Patil *et al.* 1964; Ramamirtham and Patil, 1965).

For the present study, salinity data for the entire west coast (Fig. 2) have been taken from the above two reports for the near shore stations only (20 m approximate depth).

Source of data, station numbers, stations and values of salinity, and temperature have been presented in Table 2.

The salinity varies from 33.7 ‰ (off Kanniyakumari) to 36.0 ‰ (off Dahanu). Besides some local variations, there is a continuous increase in salinity from south to north. Some later reports (*Darshak* report, 1974; Anand *et al.* 1968; R. V. *Gaveshani* Cruise Report 72, 1980) also confirm the increase in salinity from south to north.

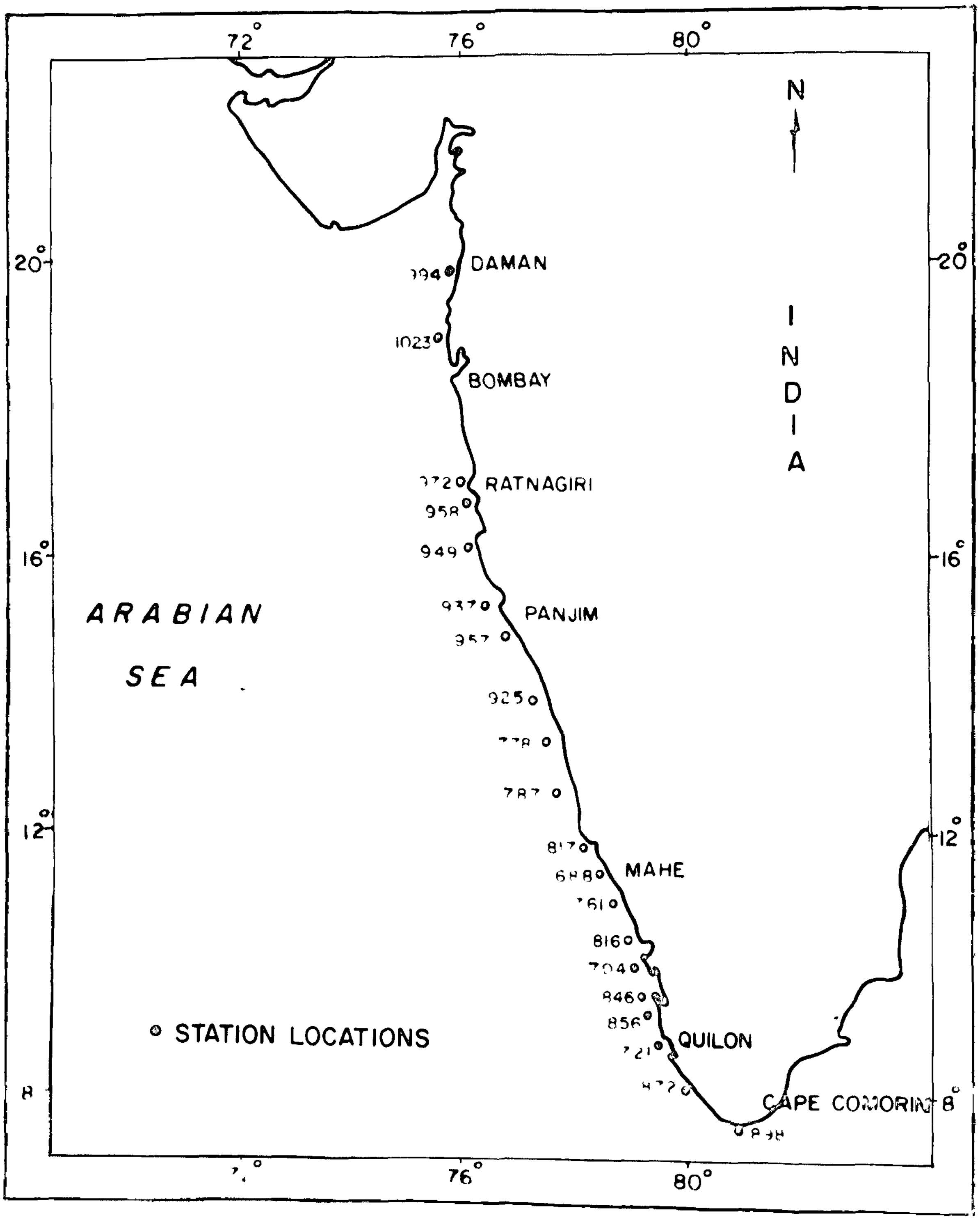
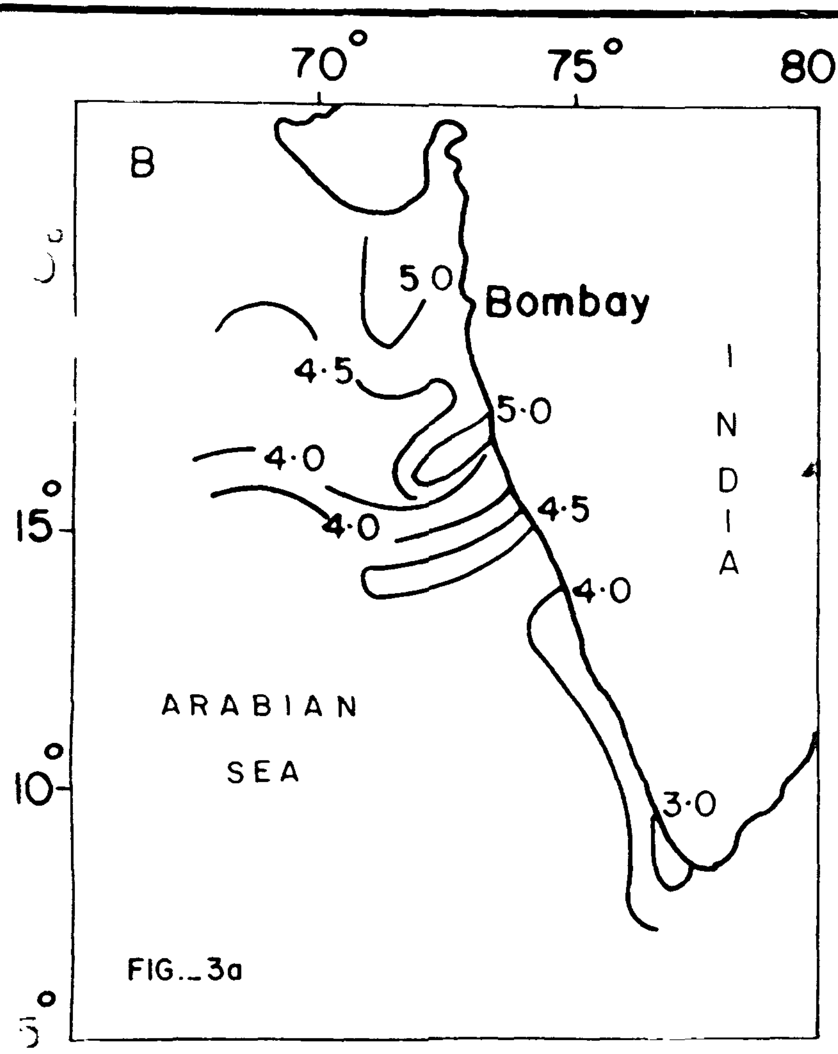


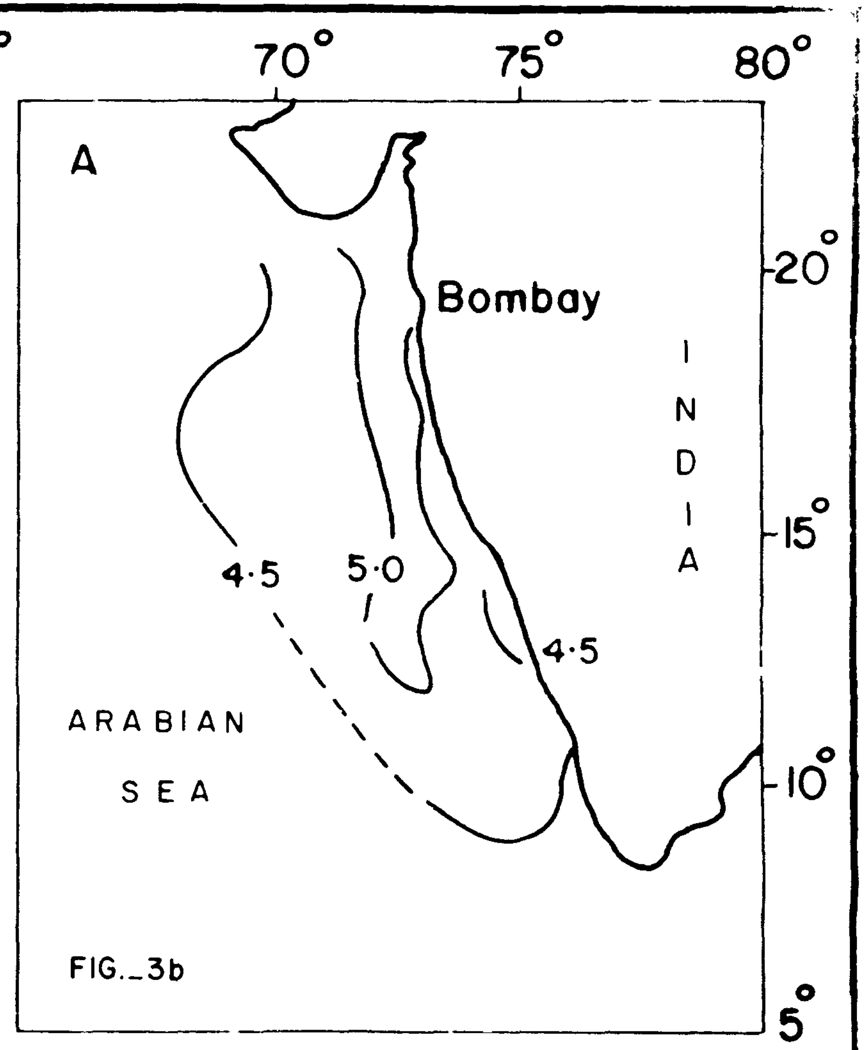
FIG._2 STATION LOCATIONS FOR TEMPERATURE AND SALINITY STUDIES.

TABLE 2: SHOWING SALINITY AND TEMPERATURE VALUES AT DIFFERENT STATIONS WITHIN THE INNER SHELF, WEST COAST, INDIA

S.No.	Reports	Station No	Station location	Salinity (‰)	Temperature (°C)
1.	Ramamirtham and Patil (1965)	898	Kanniyakumari	33.7	27.5
2.		872	Trivandrum	35.0	28.0
3.		721	Quilon	34.5	28.5
4.		856	Kaayamkulam	34.0	28.0
5.		846	Allepy	34.5	28.0
6.		704	Cochin	34.0	28.0
7.		816	Cranganore	34.5	28.0
8.		761	Ponnani	34.5	28.0
9.		688	Calicut	34.5	28.0
10.		817	Cannanore	34.5	28.0
11.		787	Bekal	35.0	28.5
12.		778	Mangalore	35.0	28.5
13.		925	Hanaara	36.0	28.5
14.		957	Karwar	35.5	29.0
15.		937	Marmagao	35.5	28.8
16.		949	Malvan	35.5	28.0
17.		958	Ratnagiri (N)	35.6	29.5
18.	Patil et al (1964)	972	Ratnagiri (S)	36.0	29.0
19.		1023	Bombay	36.0	29.0
20.		994	Dahanu	36.0	30.0



SURFACE DISTRIBUTION OF OXYGEN (ml/l) ALONG WEST COAST, INDIA.



HORIZONTAL DISTRIBUTION OF OXYGEN (ml/l) AT 20m DEPTH, WEST COAST OF INDIA.

3.2.3.2 Temperature

Like salinity, data on temperature is also scattered. Out of a few studies, Patil et al. (1964), Ramamirtham and Patil (1965), and Anand et al. (1968) have made significant contributions.

Temperature data taken from Patil et al. (1964), and Ramamirtham and Patil (1965) are given in Table 2. The values are for nearshore stations and show a variation from 27.5°C (off Kanniyakumari) to 30°C (off Dahanu). It was premonsoon recordings and shows an increase of 2.5°C from south to north along the west coast.

3.2.3.3 Oxygen

Oxygen data were taken from the studies of Anand et al. (1968). Two maps have been taken - one for O_2 variation in surface water (Fig. 3a) and the other for O_2 variation at 20 m depth (Fig. 3b). Oxygen content in surface water does not vary much (4.5 to 5.0 ml/l) but at 20 m depth, it ranges from 3.0 ml/l in the south to 5.0 ml/l in the north with some local variations.

3.2.3.4 Phosphorus

Murty et al. (1968) studied variation in total phosphorus

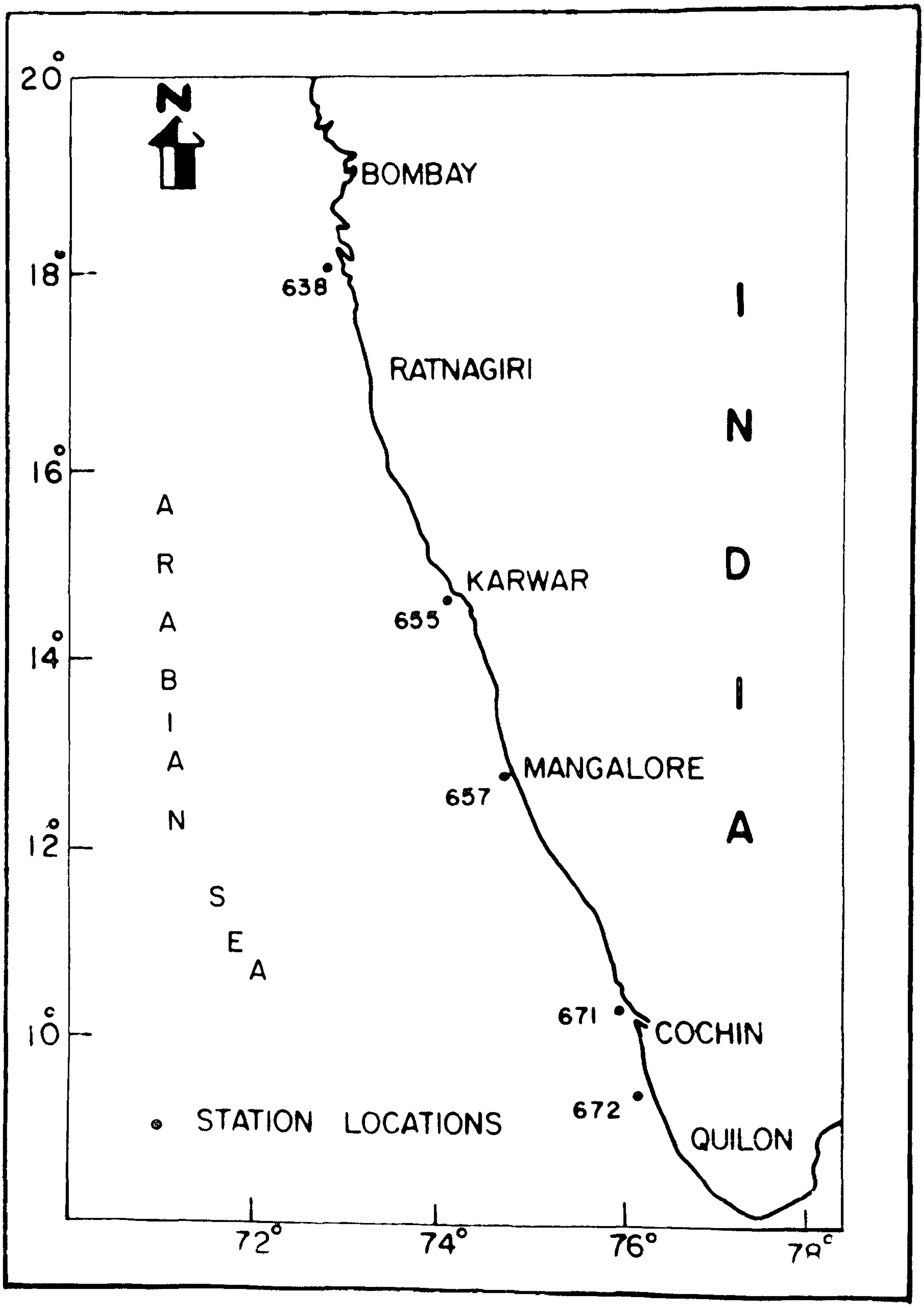


FIG._4 STATION LOCATIONS FOR PHOSPHORUS DISTRIBUTION, WEST COAST, INDIA.

TABLE 3: SHOWING DISTRIBUTION OF PHOSPHORUS WITHIN SEDIMENTS OF INNER SHELF, WEST COAST, INDIA

Locality	Station No.	Depth in m	Type of sampler	Sediment level in inches	Total phosphorus in microgram per gram of silt
Off Bombay	638	23.8	Corer	0 - 4	410
Off Karwar	655	23.0	Corer	0 - 4	110
Off Mangalore	657	18.3	Corer	0 - 4	180
Off Cochin	671	23.8	Snapper	0 - 4	730
Off Ambalapuzza	672	18.3	Corer	0 - 4	1,137

(After Murty, Reddy, Varadachari, 1968)

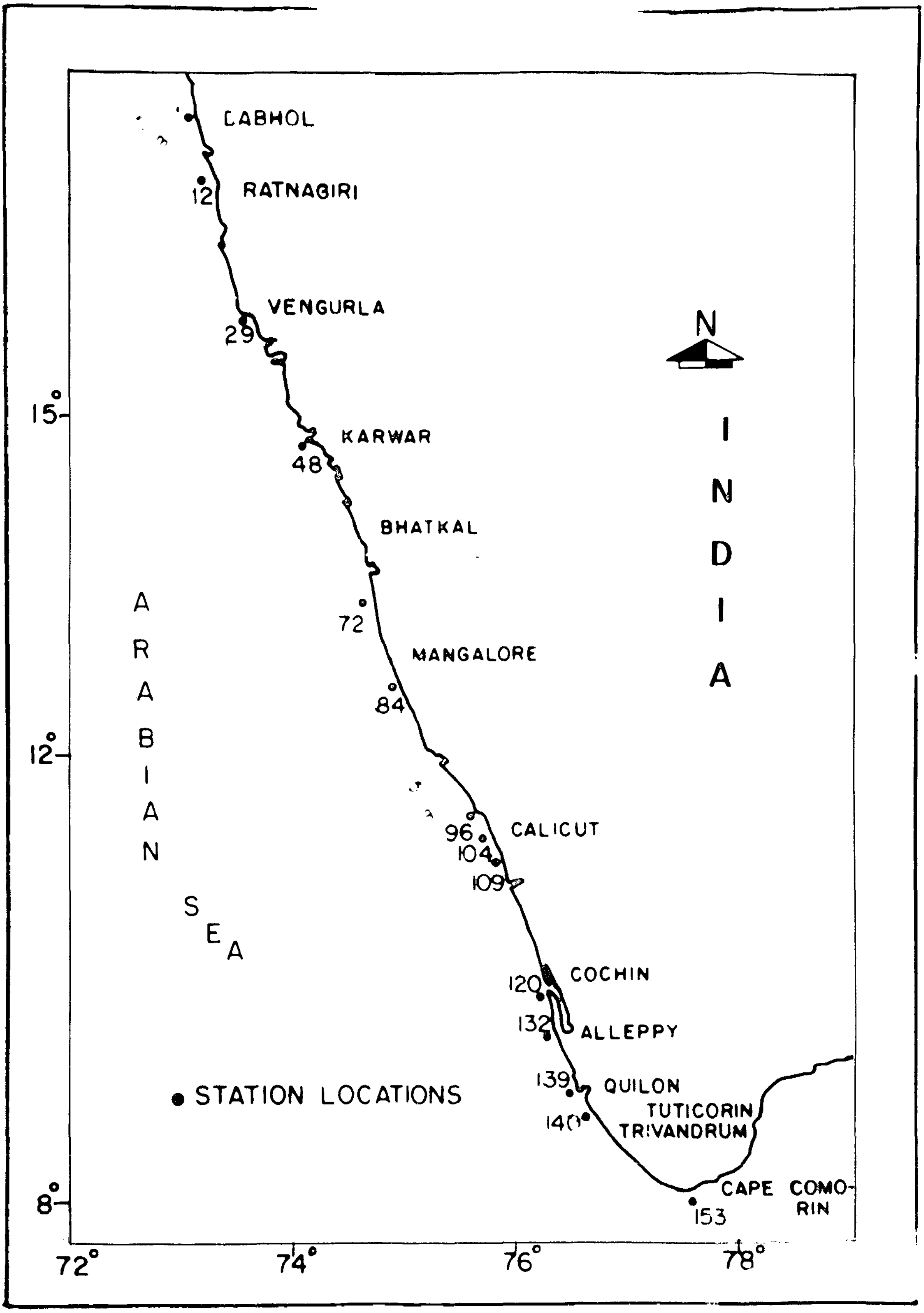


FIG.- 5. STATION LOCATIONS FOR ORGANIC CARBON DISTRIBUTION ALONG THE WEST COAST INDIA.

content in sediments along the west coast of India. This study was based on samples collected during the 25th and 26th cruises of I.N.S. KISTNA from the depth zone 18 to 677 m.

Stations from shelf region and the relevant data has been taken from the above paper and presented here (Fig. 4; Table 3). Except for Bombay coast, values of total phosphorus increase from north to south.

3.2.3.5 Organic carbon/matter

Organic carbon data from the west coast is well documented (Wieseman, 1940; Murty *et al.* 1969; Gogate *et al.* 1970; Kidwai and Nair, 1972; Marching, 1972; Setty and Rao 1972; Paropkari et al. 1978; Ambre 1979, (personal communication).

In the present work, data of Ambre (1979) based on cruise nos. 2 and 17 of R. V. Gaveshani have been taken and a composit map (Fig. 5) has been prepared taking samples from 15 to 25 m depth zone. Sample locations, depth, and organic matter content have been displayed in Table 4. Data of organic matter is plotted against latitude which shows rapid increase in organic matter from 8°N to 11°N

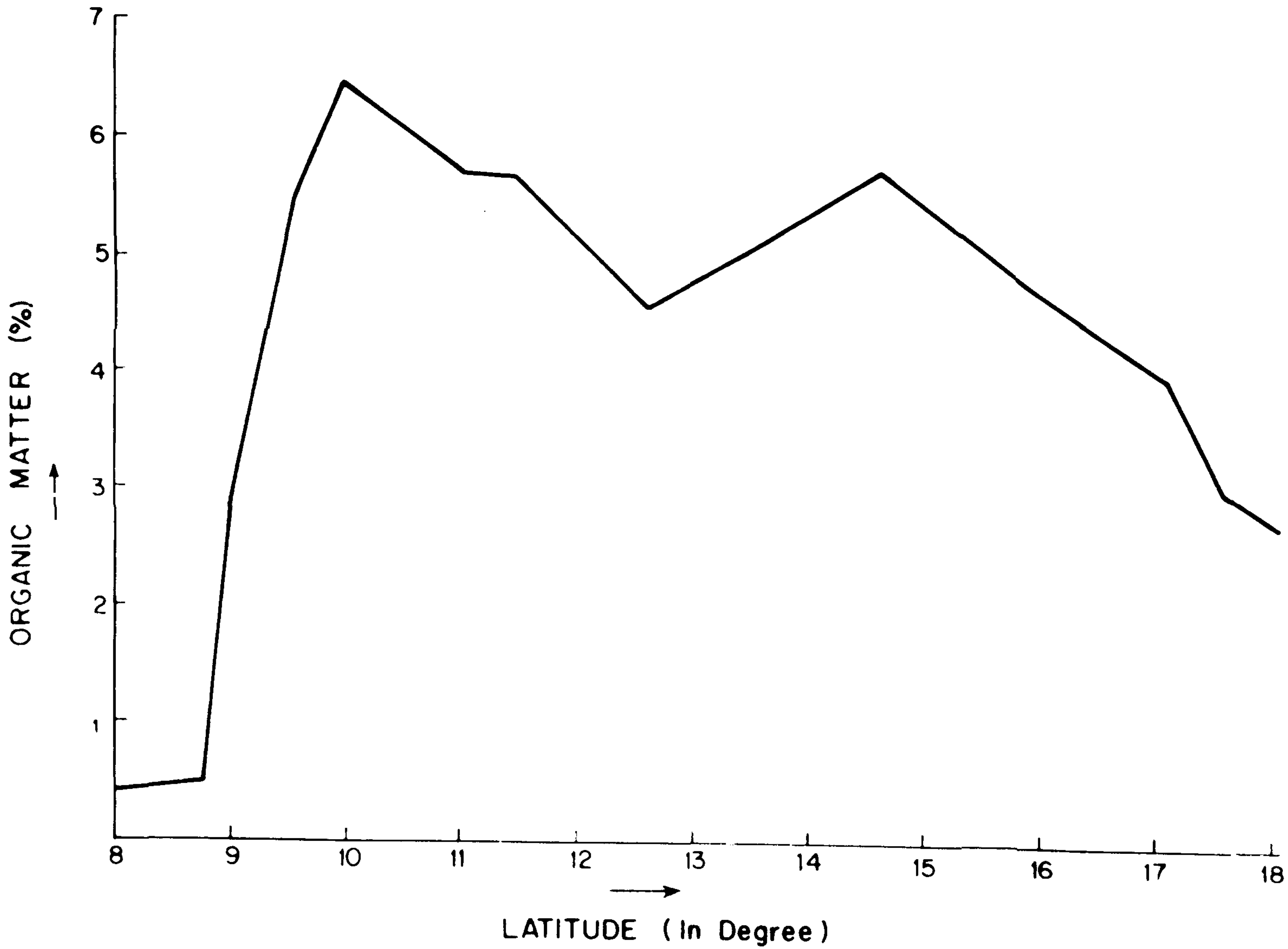


FIG._6 LATITUDINAL VARIATION OF ORGANIC MATTER ALONG WEST COAST, INDIA.

TABLE 4: SHOWING ORGANIC MATTER (%) VALUES IN DRY SEDIMENTS FROM INNER SHELF, WEST COAST, INDIA

Sample	Depth m	Latitude	Longitude	Substrate	Organic matter (%)
Off Bombay	10	18°	-	Clay	2.77
G17/1	15	17°35'	73°06'	Silty clay	3.05
G17/12	24	17°02'	73°12'	"	4.14
G17/29	20	15°50'	73°33'	"	4.84
G17/48	18	14°32'	74°15.5'	Clayey silt	5.8
G17/72	20	13°22'	74°30'	"	5.0
G17/84	18	12°36'	74°52	"	4.6
G17/104	22	11°26.5	75°34'	-	5.6
G17/109	21	11°03'	75°46'	"	5.7
G17/120	20	9°54'	76°14'	"	6.5
G17/132	18	9°30'	76°14'	"	5.5
G17/139	25	8°58'	76°26'	Sand clay	2.9
G17/140	30	8°40'	77°35	Sand	0.5
G17/153	30	8°00'	77°35.4	Sand	0.4

(Unpublished data, Ambre (1979) personal communication)

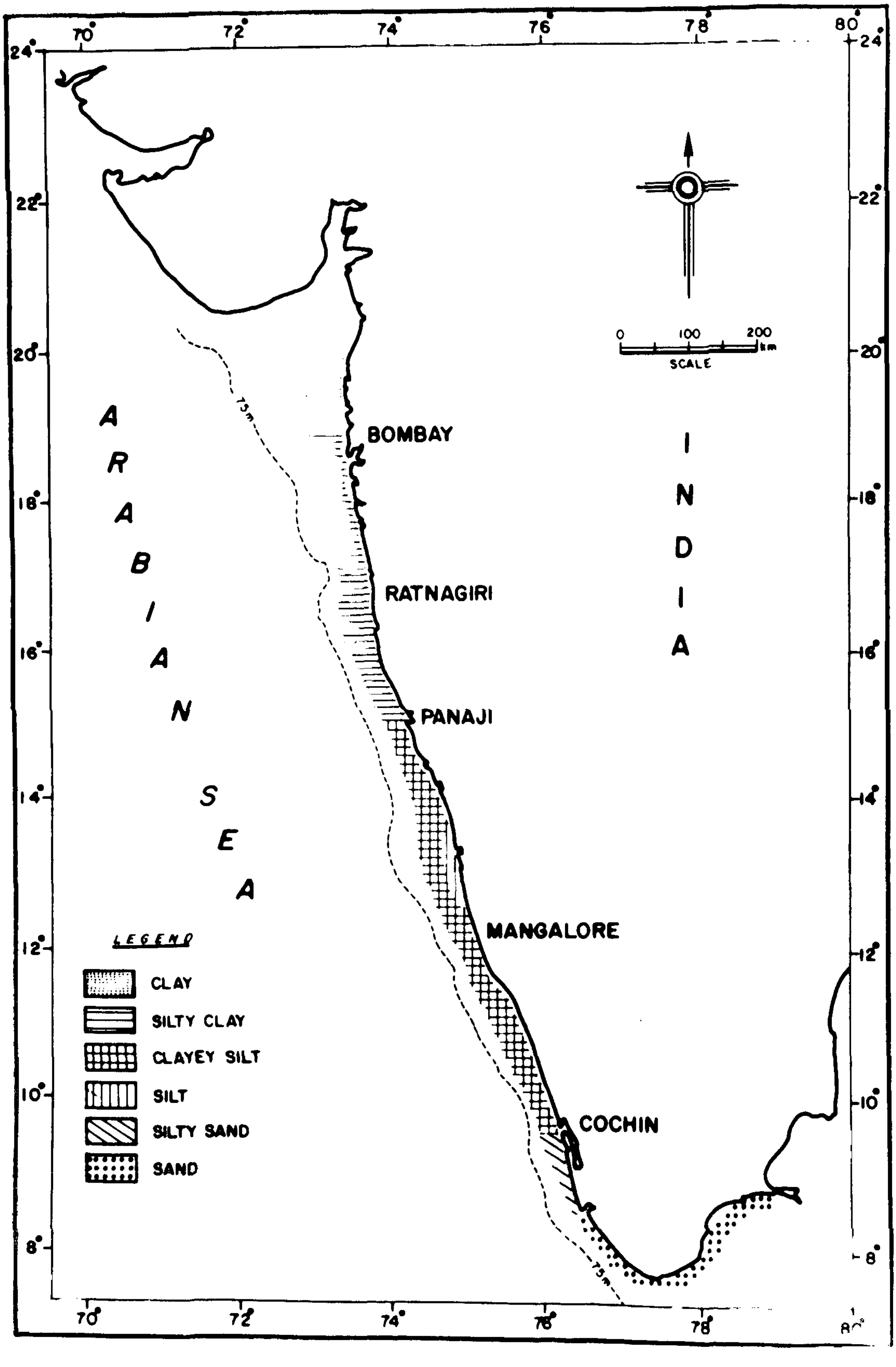


FIG._7 SEDIMENT DISTRIBUTION IN INNER SHELF ALONG WEST COAST, INDIA and then it decrease gradually with slight local variations (Fig. 6). Low values of organic matter in extreme south are mainly due to sandy substrate.

3.2.4 Sediments distribution

Hendrix (1958) studied the relationship of foraminifera to their sedimentary environment and this trend has been followed by several later workers. During the marine sediments transportation, foraminiferal tests behave as sedimentary particles. Since no beach fauna live on beach itself but are derived from the nearby shelf region along with the sediments, it was desirable to study the distribution of sediments along the west coast of India.

3.2.4.1 Sediments distribution in inner shelf, off west coast

Sediment distribution off the west coast of India is well documented (Schott, 1968; Nair and Pylee, 1968; Nair 1971; Stackelberg, 1972; Hashimi and Nair, 1976; Hashimi *et al.* 1978a, 1978b). Based on R. V. Gaveshani data (Hashimi, 1979, personal communication), a map for the distribution pattern of sediments from inner shelf region along the west coast of India, has been prepared (Fig. 7).

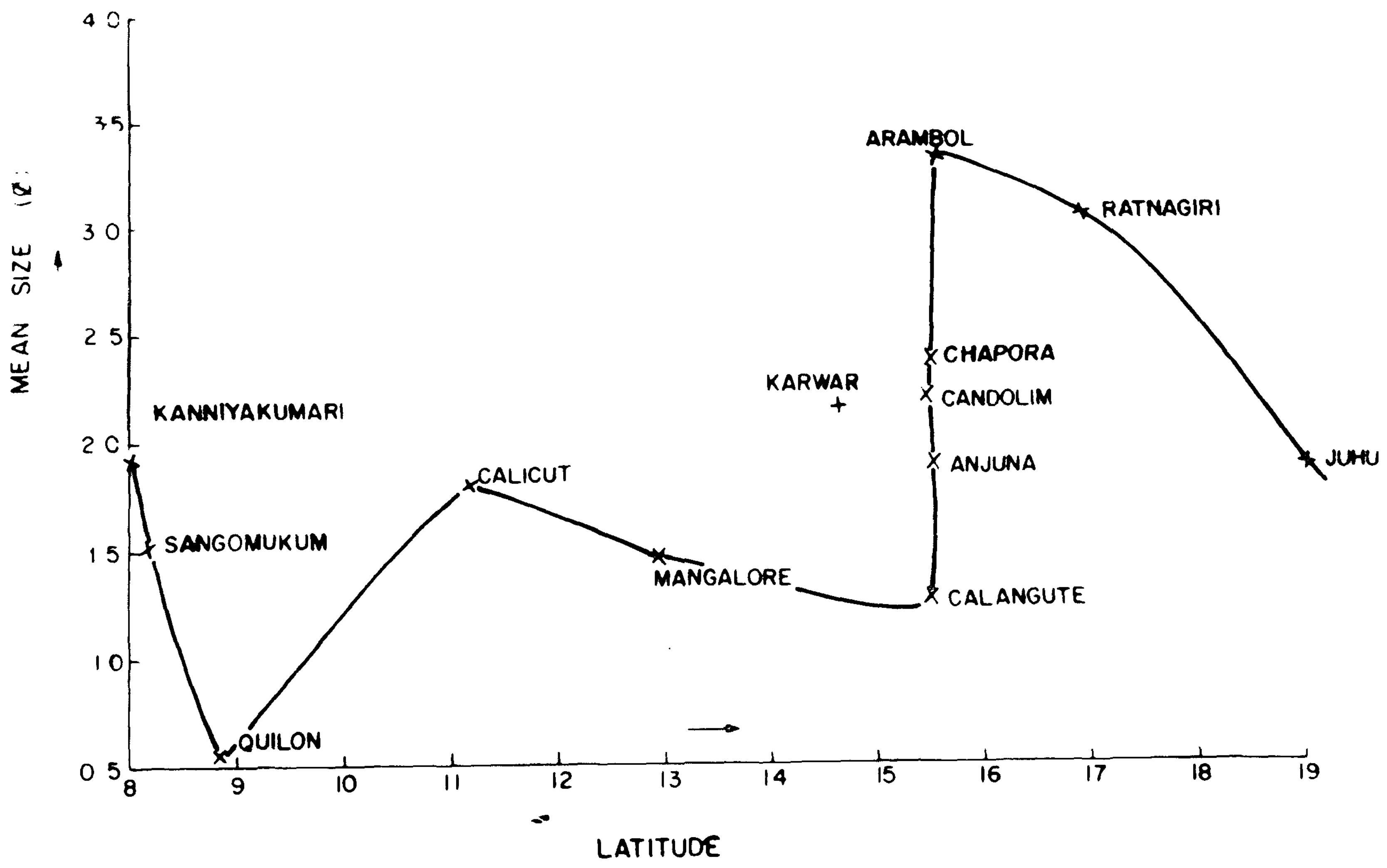


FIG._8 VARIATION IN MEAN SIZE OF BEACH SEDIMENTS ALONG WEST COAST, INDIA.

3.2.4.2 Mean size analysis of Beach Sands

In addition to above, variation in the inner shelf, grain size analysis of 13 samples were made to study mean sand size variation along the sandy beaches of west coast and possible variation, if any, with the distribution pattern of foraminifera.

Material and Methods

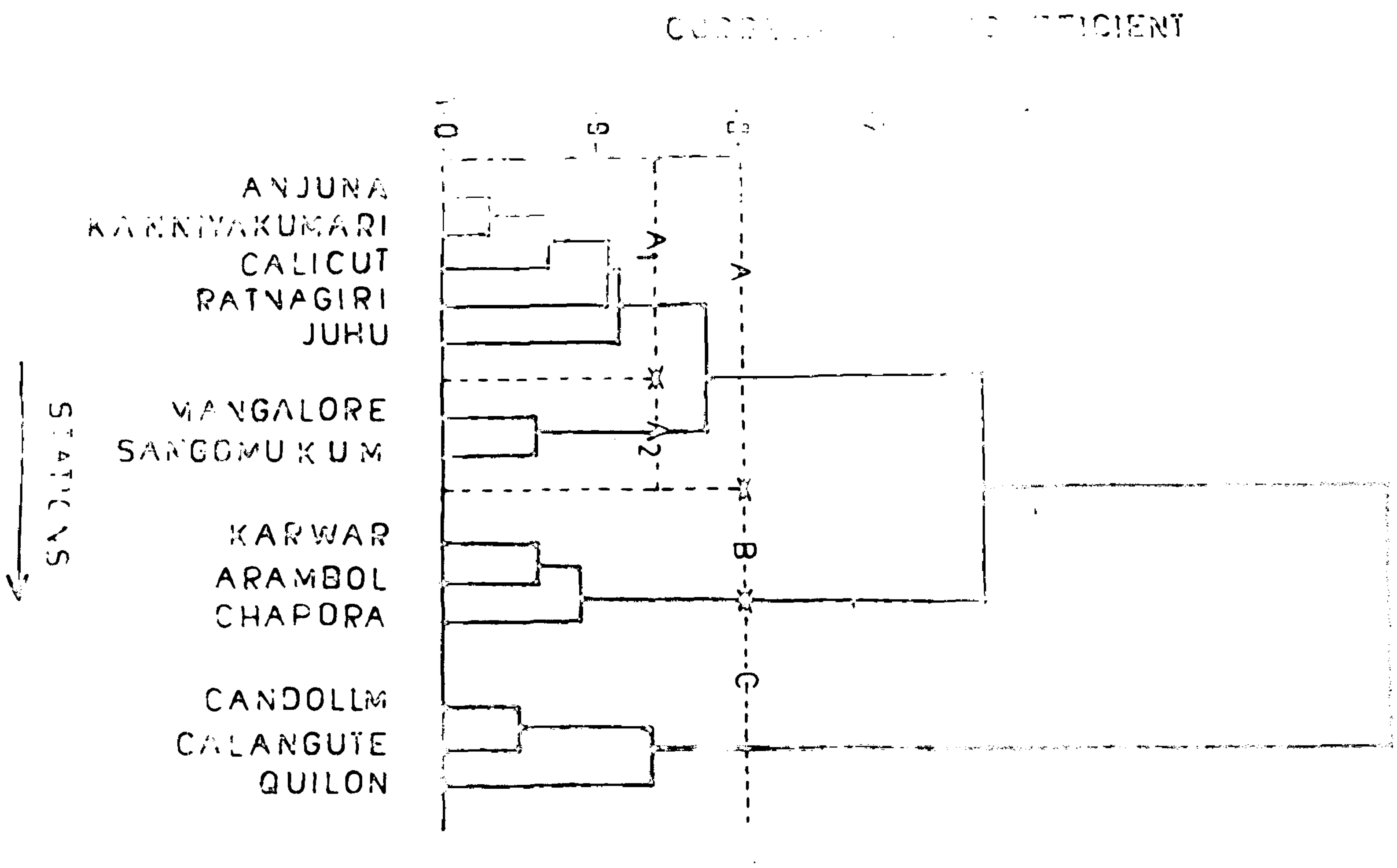
For grain size analysis, the samples were oven dried at 60°C. 25 gm of each sample was then taken for sieve analysis on a set of ASTM standard sieve at an interval of ½ phi down to 4 phi (.0625 mm). Each sieve fraction was weighed on 'Mettler' single pan balance (Appendix I). Analysis of mean size and other parameters were then computed on TDC 316 computer based on Folk and Ward's (1957) formulae (Table 5). Data of mean sand size was then plotted against latitude (Fig. 8).

Q - mode cluster analysis of mean sand size data

For a clear picture of grouping of all sandy beaches along the west coast with reference of nature of sand, a Q-mode cluster analysis technique has been applied. For this analysis, weight of each fractions as well station were taken as variable factors. The correlation coefficients (γ) were calculated between station to station.

TABLE 5: SHOWING VARIOUS SEDIMENTARY PARAMETERS OF BEACH SANDS, WEST COAST, INDIA

S.No.	Name of stations	Sedimentary Parameter: Mean sand size Mz	Standard Deviation	Skewness	Kurtosis	Normal K_G	Sand size
1.	Juhu	1.876	0.999	- 0.109	0.913	0.477	Medium
2.	Ratnagiri	3.051	0.192	- 1.209	-0.376	-7.073	Very fine
3.	Arambol	3.350	0.241	- 1.237	-1.025	40.743	Very fine
4.	Chapora	2.387	0.491	0.103	0.933	0.483	Fine
5.	Anjuna	1.885	0.791	- 0.224	1.551	0.623	Medium
6.	Calangute	1.265	0.823	- 0.251	1.331	0.571	Medium
7.	Candolim	2.457	0.168	- 0.727	1.162	0.587	Fine
8.	Colva	2.075	1.016	- 0.371	0.989	0.497	Fine
9.	Karwar	2.209	0.685	- 0.101	0.917	0.477	Fine
10.	Mangalore	1.434	0.878	- 0.384	1.280	0.561	Medium
11.	Calicut	1.796	0.767	- 0.145	1.059	0.514	Medium
12.	Quilon	0.563	0.889	- 0.623	1.044	0.511	Medium
13.	Sangomukham	1.512	0.449	- 0.253	1.823	0.646	Medium
14.	Kanniyakumari	1.951	0.557	- 0.156	1.356	0.852	Medium



ANJUNA
CALICUT
RATNAGIRI
JUHU
MANGALORE
KARWAR
ARAMBOL
CHAPORA
CANDOLIM
CALANGUTE
QUILON
A
A1
A2
B
C

For computing correlation coefficient (r) TDC 316 computer was used (Appendix No. 2) by applying following formula:

$$r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{(N\Sigma X^2 - (\Sigma X)^2)^{\frac{1}{2}} \; (N\Sigma Y^2 - (\Sigma Y)^2)^{\frac{1}{2}}}$$

Where r = Correlation coefficient

x = Percentage of one variable in sample A

y = Percentage of some variable in sample B

N = Number of observations

A total of 13 stations were used in this analysis. After computation, correlation coefficients were obtained. For clustering "weighed pair group" method of Sokal and Sneath (1963) was applied. The results were plotted in the form of a two-dimensional heirarchy dendrogram (Fig . 9).

Results

At 0.8 level of clusterings, three clusters were recognised. Description of each cluster is given below:

(A) Cluster A consists of 7 stations. At further increasing degree of correlation to 0.85, this cluster again breaks up into two sub-clusters--A_1 and A_2. Cluster A_1 consists of Juhu, Ratnagiri, Anjuna and Kanniyakumari while A_2 is composed of Mangalore and Sangomukum.

(B) Cluster B consists of 3 stations, namely, Arambol, Chapora and Karwar.

(C) Cluster C consists of 3 stations Calangute, Condolim and Quilon.

3.2.4.3 Conclusion

The sediments distribution of inner shelf (Fig. 7) reveals that size of sediments gradually increase from north to south or higher latitude to lower latitude. However, the gradation is very slow but in extreme south, the sediments abruptly become coarse. The cluster analysis data of beach sands noted above (Fig. 9) shows that the nature of beach sand is independent of latitudinal variation and is not in accordance with the inner shelf sediments. It might be possibly due to local factors.

3.3 MATERIAL AND METHODS

The present work is based on a total of 260 samples collected during September - October 1976 from 13 sandy beaches along the west coast of India.

3.3.1 Field Methods

Following a grid pattern, 20 samples from each sandy beach were collected in four traverses. A preliminary examination of the foraminiferal assemblages belonging to different samples representing small area does not show any significant difference. Hence, all samples from each beach are treated collectively as one for the purpose of the present study.

3.3.2 Laboratory Methods

Each sample was screened through a sieve (ASTM - 35) and 500 g of material was subjected to splitting by a micro-splitter. A fraction weighing 5 g (by a single pan electronic balance) was taken and examined under stereoscopic binocular microscope for micropaleontological investigation. All the tests of foraminifera were picked with a fine, moist, sable-hair brush for working out quantitative studies. Entire tests were separated for identification purpose. The rest of material recovered through the sieve was treated with carbon-tetra chloride (CCl_4) for concentrating rare foraminifera tests. The picked material was then arranged in faunal group slides for identification and study.

Illustrations of all the species are by microphotographs.

CHAPTER 4

SYSTEMATIC PALEONTOLOGY

4.1 CLASSIFICATION

Amongst various classifications of Foraminiferida, the one proposed by Loeblich and Tappan (1964), has been followed in the present study. Earlier, different workers advocated different classifications for the Order emphasising a few characters which they considered important while ignoring other, equally significant, features of systematic value. The classification proposed by Loeblich and Tappan (op. cit.) embraces nearly all the observable characters and also takes into consideration the phylogenetic relationship. Thus, it has a 'horizontal' approach and is most up to date.

In the present study, the different genera of Foraminiferida have been arranged according to the classification adopted by Loeblich and Tappan (1964) whereas different species within a single genus are arranged alphabetically. The synonymies have been greatly reduced and only those references which either refer to important shift in the generic name or which have species similar to our, have been incorporated along with all possible references from the Indian waters.

Different workers have used different criteria for distinguishing different sides of trochoid or partially trochoid foraminiferal tests. Some authors used the terms dorsal and ventral while others prefer to designate them as spiral and umblical. It is not difficult to differentiate both sides in high-spired tests, but the real problem crops up when low-spired and partially trochoid tests are examined. An excellent review of this problem has been given by Belford (1966). According to him, the side nearest to the proloculus should be treated as dorsal while opposite is ventral. In the present study, Belford's view has been followed to distinguish dorsal side from the ventral in different trochoid species.

Dimorphism is an important phenomenon which some times controls the shape and size of the test. Therefore, in the present investigation an attempt has been made to work out dimorphism wherever possible.

4.2 REPOSITORY OF TYPE MATERIAL

All the illustrated specimens have been deposited in the micropaleontological collection of the Geology Department, Aligarh Muslim University, Aligarh, and in the text, the number of foraminiferal specimens have been prefixed with the word AMUGD cat No.

4.3 SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Herouard, 1896

Superfamily LITUOLACEA de Blainville, 1825

4.3.1 Family LITUOLIDAE de Blainiville, 1825

Subfamily LITUOLINAE de Blainiville, 1825

Genus AMMOBACULITES Cushman 1910

Ammobaculites persicus Lutze

Plate 1, figure 1

Ammobaculites persicus LUTZE, 1974, page no. 11, pl. 2, figs. 27-35.-

SEIBOLD, 1975, pp. 178-179, pl. 2, figs. 11-a-b.

Dimensions (in mm): Length 0.39 to 0.43, width 0.30 to 0.35, thickness 0.10 to 0.11.

Remarks: A. persicus is frequent to rare in our material. Lutze (1974) reported for first time this species from Persian Gulf. In his material, specimens with uncoiled end were dominating. However, Seibold (1975) reported this species from coast and lagoon of Cochin with short or missing uncoiled part of the test. In our material both the types of tests are present but tests with short or without uncoiled portion are more common. However, aperture is the same, i.e., terminal, slit-like and somewhat infolded. Our specimens closely resemble to specimen sketched by Seibold (1975).

Repository of type material: AMUGD cat. No. MF 184

4.3.2 Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus TEXTULARIA Defrance, 1924

Textularia agglutinans D'orbigny

Plate 1, figure 4

Textularia agglutinans D'ORBIGNY, 1839, pp. 32-34, pl. 1, figs. 17-18.- BRADY, 1884, pl. 43, figs. 1-3.- GANAPATI and SATYAVATI, 1958, pp. 106, pl. 1, fig. 14.- SETHULEKSHMI AMMA, 1958, p. 39, pl. 2, fig. 57.- ANTONY, 1968, pp. 20-21, pl. 1, fig. 9.- RAO, 1971b, p. 156, fig. 9.- ALMEIDA and SETTY, 1972, p. 96, pl. 1, figs. 6-8.- ZOBEL, 1973, pl. 1, fig. 28.- RAO and RAO, 1974, pl. 1, fig. 7.

Dimensions (in mm): Length 0.62 to 0.68, width 0.44 to 0.45.

Remarks: T. agglutinans is a well-known shallow water, cosmopolitan, species. Norton (1930) reported this species from beach to 110 m depth with temperature range 20 to 27°C from Florida and west Indian region.

From east coast of India, Ganapati and Satyawati (1958) recorded T. agglutinans from Vishakhapatnam at 44 to 190 m depth and 13.3 to 24.4°C temperature ranges. Almeida and Setty (1972) reported this species from Vishapatnam at 55 to 74 m depth range. Rao and Rao (1974) recorded it from Guddagedda estuary, with organic carbon 0.40 to 2.42%. However, from west coast, Sethulekshmi Amma (1958) found it from near Travancore and Antony (1968) from Kerala coast (22 to 183 m). From the north-eastern part of Arabian sea, Rao (1971b) recorded this species at 64 m depth and 23.89 to 24.71°C temperature range within sandy substrate.

Summary of ecological data: Depth upto 190 m, temperature 20 to 29°C, organic carbon 0.4 to 2.42%.

Repository of type material: AMUGD cat. No. MF 185

<u>Textularia</u> <u>conica</u> D'orbigny

Plate 1, figure 3

<u>Textularia</u> <u>conica</u> D'ORBIGNY, 1839, p. 143, pl. 1, figs. 19-20.- BRADY, 1884, p. 365, pl. 43, figs. 13-14, pl. 113, fig. 1.- BHATIA, 1956, p. 17, pl. 2, fig. 2.- SETHULEKSHMI AMMA, 1958, p. 40, pl. 2, fig. 59a-b.- ANTONY, 1968, p. 23, pl. 1, fig. 13.- RAO, 1971b, p. 156, fig. 10.- ALMEIDA and SETTY, 1972, p. 96, pl. 1, figs. 14-15.- SEIBOLD, 1975, pp. 179-180.

<u>Dimensions (in mm)</u>: Length 0.37 to 0.38, width 0.23 to 0.24.

<u>Remarks</u>: <u>T. conica</u> is a cosmopolitan species. Said (1949) recorded it at 17 to 24 m depth from Red Sea and Uchio (1962) reported it from beach sand of Shiraki and Kushimoto and near-shore sediments along the coast of Wakayama-ken, Japan.

From the west coast of India, Bhatia (1956) found <u>T. conica</u> at Bhogat beach and Sethulekshmi Amma (1958) from Travancore coast. Antony (1968) recorded it from Kerala coast at 22 to 183 m depth range while Rao (1971b) found it in the north-east part of the Arabian Sea at 64 m depth and 24.71°C temperature with sandy substrate.

Seibold (1975) reported _T_. _conica_ from coast and lagoon of Cochin. From east coast of India, Almeida and Setty (1972) found it near Vishakhapatnam at 35 to 203 m depth range.

Summary of ecological data: Depth up to 203 m, temperature 24.7°C.

Repository of type material: AMUGD cat. No. MF 186

<u>Textularia</u> <u>foliacea</u> Heron-Allen and Earland

Plate 1, figure 5.

<u>Textularia</u> <u>foliacea</u> HERON-ALLEN and EARLAND, 1915, p. 628, pl. 47, figs. 17-20.- BHATIA, 1956, p. 17, pl. 1, fig. 1.- SETHULEKSHMI AMMA, 1958, p. 41, pl. 2, fig. 61.- ANTONY, 1968, p. 22, pl. 1, fig. 12.

<u>Dimensions (in mm)</u>: Length 0.82 to 0.90, width 0.35 to 0.40.

<u>Remarks</u>: This characteristic, Indo-Pacific, species was reported for the first time from Indian waters by Bhatia (1956) from Bhogat beach. Sethulakshmi Amma (1958) recorded it from Travancore coast and Antony (1968) found it in 5 sections along Kerala coast at 22 to 183 m depth range.

<u>Repository of type material</u>: AMUGD cat. No. MF 187

4.3.3 Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus TROCHAMMINA Parker and Jones, 1859

Trochammina hadai Uchio

Plate, figure 2

Trochammina hadai UCHIO, 1962, p. 387, pl. 18, figs. 9a-c.- MATOBA, 1970, p. 62, pl. 1, figs. 14a-c, 15a-c.- SEIBOLD, 1975, p. 180, pl. 1, figs. 2a-b.

Dimensions (in mm): Length 0.48, width 0.35, thickness 0.24.

Remarks: *T. hadai* was originally described by Uchio (1962) from Shinano estuary, Japan. He separated *T. hadai* from *T. globigeriniformis* Parker and Jones on the basis of its restricted but distinct occurrence in the inner bay facies of bays and lagoons of Japan. Matoba (1970) also recorded dominant population of this species from inner shelf region of Matsushima Bay, Miyagi prefecture, north-east Japan but it was present at almost all the stations. Ecological data of the above area as given by Matoba is as follows:

Temperature: Summer - Surface water 26°C to 29°C
Winter - Surface water 1°C to 4°C (or more)

Chlorinity: Summer - Surface water 14 to 16%.
Bottom water 14 to 17%.
Winter - Surface water 17 to 18%.

pH: Summer - Bottom water 7.6 to 8

Organic carbon: 3 to 4%

Total nitrogen: 1 to 2 per mil (near bay mouth)
2 to 3 per mil (middle)

Total sulfide: 0.5 to 1.0 per mil

From the Indian region, Seibold (1975) observed dominant living occurrence of *T. hadai* from 1.3 m depth from lagoon of Cochin. According to her (Seibold, 1975, p. 180), "It resembles closely the Japanese form. Uchio often found five chambers in the last whorl. Our specimens have mostly four. *Tr. globigeriniformis* normally has 3 chambers in the last whorl". Our specimens closely resemble to one figures and described by Seibold. (*op. cit.*).

Repository of type material: AMUGD cat. No. MF 188

Suborder MILIOLINA Delage and Herouard, 1896

Superfamily MILIOLACEA Ehrenberg, 1839

4.3.4 Family NUBECULARIIDAE Jones, 1875

Subfamily SPIROLOCULININAE Wiesner, 1920

Genus SPIROLOCULINA D'orbigny, 1826

Spiroloculina aequa Cushman

Plate 1, figure 10

Spiroloculina antillarium var. aequa CUSHMAN, 1932. p. 38, pl. 9, figs. 13 a-b

Spiroloculina aequa BRAGA, 1960, p. 82, pl. 6, figs. 10-11.- Seibold, 1975, p. 181, pl. 1, figs. 10-11.

Dimensions (in mm): Length 0.44 to 0.46, width 0.23 to 0.24, thickness 0.09 to 0.10.

Remarks: S. aequa is an Indo-Pacific species. Originally, it was described as S. antillarium var. aequa by Cushman. It is similar to S. antillarium but differs in having a smooth test. Seibold (1975) recorded it for the first time from Indian waters near Cochin and noted its rare occurrence in deep water. According to her (Seibold, 1975, p. 181) "Spiroloculina aequa resembles Sp. lavigata in original Cushman & Todd 1944 from which it differs (after C & T) only by its more slender shape. Probably, both species belong together".

Repository of type material: AMUGD cat. No. MF 189.

Spiroloculina antillarium D'orbigny

Plate 1, figure 8

Spiroloculina antillarium D'ORBIGNY, 1839, p. 166, pl. 9, fig. 34.– BRADY, 1884, p. 155, pl. 10, figs. 21 a-b.– GANAPATI and SATYAVATI, 1958, p. 114, pl. 2, fig. 34.– SETHULEKSHMI AMMA, 1958, p. 3, pl. 1, fig. 2.– ROCHA and UBALDO, 1964b, p. 647, pl. 2, fig. 6.– BHALLA, 1968, p. 378, pl. 1, fig. 7.– ANTONY, 1968, p. 34, pl. 2, fig. 7.– RAO, 1970 a, p. 592, pl. 2, fig. 20

Dimensions (in mm): Length 0.46 to 0.47, thickness 0.08 to 0.09.

Remarks: From the east coast of India, Ganapati and Satyavati (1958) recorded S. antillarium from Vishakhapatnam coast at 98 m depth and 17.8°C temperature. Bhalla (1968) obtained it from Vishakhapatnam beach. However, from the west coast, Rocha and Ubaldo (1964b) reported S. antillarium from Baga beach and Sethulekshmi Amma (1958) and Antony (1968) from near-shore regions of Kerala Coast.

Repository of type Material: AMUGD cat. No. MF 190.

Spiroloculina communis Cushman and Todd

Plate 1, figure 6.

Spiroloculina communis CUSHMAN and TODD, 1944, p. 63, pl. 9, figs. 4-7, 7-8a-b.- BHALLA, 1968, p. 380, pl. 1, figs. 6a-b.- SEIBOLD, 1975, pp. 180-181.

Spiroloculina excavata BRADY, 1884 (non d'Orbigny), p. 151, pl. 9, figs. 5-6.- SETHULEKSHMI AMMA, 1958, p. 3, pl. 1, fig. 3.- ANTONY, 1968, p. 35, pl. 2, fig. 8.

Dimensions (in mm): length 0.56 to 0.74, width 0.30 to 0.45, thickness 0.101 to 0.120.

Remarks: S. communis is an Indo-Pacific species. Our specimens show a great range of variation in size, width, neck, etc., and microspheric as well as megalospheric generations are present in the present assemblage. Braga (1960) recorded this species from Mozambique coast; Heron-Allen and Earland (1915) from Kerimba Archipelago; and Albani (1965) from Durban bay, South Africa.

From Indian waters, Bhalla (1968) recorded S. communis from Vishakhapatnam beach sand. Seibold (1975) obtained its rare occurrence from offshore regions off Cochin. She treated S. excavata as illustrated and described by Sethulekshmi Amma (1958) and Antony (1968) as a junior synonym of S. communis.

Repository of type material: AMUGD cat. No. MF 191.

Spiroloculina excavata D'orbigny

Plate 1, figure 7.

Spiroloculina excavata D'ORBIGNY, 1846, p. 271, pl. 16, figs. 19-21.- BHATIA, 1956, pp. 17-18, pl. 1, fig. 13.- BHATIA and KUMAR, 1976, p. 242.

Dimensions (in mm): Length 0.91 to 0.98 width 0.71 to 0.82, thickness 0.14 to 0.15.

Remarks: *S. excavata* is a cosmopolitan species. Bhatia (1956) recorded it from Juhu and Chowpatty beaches and Bhatia and Kumar (1976) from Anjidiv island near Karwar at 5 to 12 m depth, 28.7 to 30.1°C temperature 8.7 to 10.8 pH (at bottom), 33.49 to 34.99 ‰ salinity, and 4.01 to 4.37 ml/l dissolved oxygen ranges. Recently, Haake (1977) found this species at only one station from Adriatic Sea at 61 m depth.

Summary of ecological data: Depth upto 61 m, temperature 28.7 to 30.1°C, salinity 33.49 to 34.99 ‰, Oxygen 4.01 to 4.37 ml/l, and pH 8.7 to 10.8.

Repository of type material: AMUGD cat. No. MF 192.

Spiroloculina eximia Cushman

Plate 1, figure 14

Spiroloculina eximia CUSHMAN, 1922, p. 61, pl. 11, fig. 2; 1929, p. 42, pl. 8, figs. 7 a-b.- BHATIA, 1956, p. 18, pl. 1, fig. 14.- ROCHA and UBALDO, 1964a, p. 6, pl. 2, fig. 1; 1964b, p. 647, pl. 2, figs. 7-8.- BHATIA and KUMAR, 1976, p. 242 (table)

Dimensions (in mm): Length 0.84 to 0.86, width 0.4 to 0.5, thickness 0.14 to 0.15.

Remarks: *S. eximia* was described from the West Indian region by Cushman (1929). Todd and Brönnimann (1957) recorded it from near-shore (0 to 4 m) and offshore 4 to 33 m) zone, commonly in muddy substrate. Recently, Brasier (1975) reported occurrence of dead specimens of *S. eximia* in reefs and shoals around Barbuda.

From Indian waters, Bhatia (1956) reported *S. eximia* from Juhu beach, Bombay; Rocha and Ubaldo (1964a) from Baga and Gogola beaches. Recently, Bhatia and Kumar (1976) encountered this species from near-shore region of Anjidiv Island, Karwar, west-coast of India at 6 to 13 m depth, 28.5 to 29.6°C temperature, and 33.49 to 35.01 ‰ salinity ranges. *S. eximia* is known from Atlantic and Pacific Oceans, Florida, Brazil and other regions of the world.

Summary of ecological data: Depth upto 33 m, temperature 28.5 to 29.6°C, salinity 33.49 to 35.01 ‰.

Repository of type material: AMUGD cat. No. MF 193.

Spiroloculina indica Cushman and Todd

Plate 1, figure 15

Spiroloculina indica CUSHMAN and TODD, 1944, p. 71, pl. 9, figs. 32a-b.- BHATIA, 1956, p. 18, pl. 2, fig. 6.- ROCHA and UBALDO, 1964a, p. 6, pl. 2, fig. 5; 1964b, p. 647, pl. 2, fig. 9.- ZOBEL, 1973, p. 14, pl. 1, fig. 17.- BHATIA and KUMAR, 1976, p. 243 (table).

Dimensions (in mm): Length 0.42 to 0.50, width 0.20 to 0.22, thickness 0.10 to 0.14.

Remarks: S. indica was originally described by Cushman and Todd (1944) from Recent shore sands of Karachi, Pakistan, and is only known from the Arabian Sea. Bhatia (1956) described S. indica from Juhu and Bhogat beaches and Rocha and Ubaldo (1964a, b) reported it from Baga and Gogola beaches on the west coast. Recently, Bhatia and Kumar (1976) recorded this species from Anjidiv Island, near Karwar at 5 to 13 m depth range, 28.5 to 30°C temperature and 33.49 to 34.94 ‰ salinity ranges.

Repository of type material: AMUGD cat. No. MF 194.

Spiroloculina planissima Wiesner

Plate 1, figure 13

Spiroloculina planissima WIESNER, 1912, p. 209; 1923, pl. 5, fig. 29.– RAO, 1974, pl. 1, fig. 10.

Miliolites planulata LAMARK var. *c*. LAMARK, 1822, p. 613, no. 4 (c).

Dimensions (in mm): Length 0.77 to 0.82, width 0.60 to 0.71, thickness 0.18 to 0.19.

Remarks: Type specimens of *S. planissima* were obtained by Wiesner (1923) from the bottom sample from Polari Bay, Eastern Adriatic, at 1.5 m depth. Asano (1938) recorded this species from Pacific Sea bordering Japan. From the west coast of India, Rao (1974) observed *S. planissima* from the mouth of Zuari estuary at 4 m depth having 28.7°C temperature, 35.15 ‰ salinity, 0.78 µg/l phosphate, and 1.95 mg/g organic carbon.

Repository of type material: AMUGD cat. No. MF 195.

<u>Spiroloculina</u> <u>rotunda</u> D'orbigny

Plate 1, figure 12

<u>Spiroloculina</u> <u>rotunda</u> D'ORBIGNY 1826, p. 299, fig. 7.- BARKER, 1960, p. 18, pl. 9, fig. 14-15.- BRAGA and GALHANO, 1965, p. 51, pl. 6, fig. 14.

<u>Dimensions (in mm)</u>: Length 0.71 to 0.78, width 0.61 to 0.69, thickness 0.12 to 0.13.

<u>Remarks</u>: Specimens of <u>S</u>. <u>rotunda</u> in our material have almost rounded test without neck and the umblical region is almost smooth and flush. Braga and Galhano (1965) recorded it from Madeira Archipelago. This is the first report of <u>S</u>. <u>rotunda</u> from Indian water.

<u>Repository of type material</u>: AMUGD cat. No. MF 196

Spiroloculina _scita_ Cushman and Todd

Plate 1, figure 9

Spiroloculina _scita_ CUSHMAN and TODD, 1944, p. 51, 60, figs. 14, 20, 21.- BHATIA and KUMAR, 1976, p. 244, pl. 1, figs. 1-6.

Dimensions (in mm): Length 0.81 to 0.92, width 0.80 to 0.92, thickness 0.32 to 0.34.

Remarks: _S. scita_ is a robust and highly variable species of _Spiroloculina_. It has strong, oblique, ornamentation but certain specimens in our material have nearly smooth test, possibly due to abrasion. Bhatia and Kumar (1976) recorded it from Anjidiv Island near Karwar at 5 to 13 m depth, 28.5 to 30.1°C temperature, 8.7 to 10.1 pH at bottom, 33.49 to 35.01 ‰ salinity and 4.01 to 4.84 ml/l dissolved oxygen ranges.

Megalospheric and microspheric generations of _S. scita_ are present in our material and the differences between them is very marked. Specimens belonging to megalospheric generation are medium size and neck of the last chamber is close to previous chamber, while specimens of microspheric generation are of large size and the last chamber is irregular and away from the previous one.

S. scita is very similar to *S. costifera* Cushman but *S. costifera* is of almost double the size and aperture has a small phialine lip.

Repository of type material: AMUGD cat. No. MF 197.

<u>Spiroloculina</u> <u>tricarinata</u> Terquem

Plate 1, figure 11

<u>Spiroloculina</u> <u>tricarinata</u> TERQUEM (part) (non D'orbigny), 1882, p. 158, pl. 16, figs. 19, 20 (not 21).– CUSHMAN and TODD 1944, p. 10, pl. 2, figs. 19, 20 (not 21, 22).– LeCALVEZ, 1947, p. 24, pl. 2, fig. 30–31.– KAASSCHIETER, 1961, p. 153, pl. 3, fig. 9–11.

<u>Dimensions (in mm)</u>: Length 0.80 to 0.90, width 0.65 to 0.67, thickness 0.20 to 0.30.

<u>Remarks</u>: <u>S.</u> <u>tricarinata</u> was reported for first time by Terquem (1882) from the Lutelian of Paris basin. Kaasschieter (1961) recorded it from Eocene of Belgium and he also erected two new varieties, viz., <u>S.</u> <u>tricarinata</u> var. <u>belagica</u> and <u>S.</u> <u>tricarinata</u> var. <u>angulifera</u>. He (Kaasschiter, 1961, p. 153) also observed, "The number of carinae per chamber is variable; some specimens have 5 or 6 on last chamber, but the distinct tricarinata forms is the most common. Especially young specimens may have as few as two carinae".

<u>S.</u> <u>tricarinata</u> also resembles <u>S.</u> <u>tricosta</u> and <u>S.</u> <u>striatula</u>. From former, it differs in being smaller in size and oval in shape while <u>S.</u> <u>striatula</u> differs from <u>S.</u> <u>tricarinata</u> in having rounded test and less prominent neck.

<u>Repository of type material</u>: AMUGD cat. No. MF 198

4.3.5 Family MILIOLIDAE Ehrenberg, 1831

Subfamily QUINQUELOCULININAE Cushman, 1917

Genus QUINQUELOCULINA D'orbigny, 1826

Quinqueloculina agglutinata Cushman
Plate 3, figure 3

Quinqueloculina agglutinata CUSHMAN, 1917, no. 71, pl. 9, fig. 2.- ALMEIDA and SETTY, 1972, p. 98, pl. 2, figs. 9-10.

Dimensions (in mm): Length 0.57 to 0.60, width 0.41 to 0.43, thickness 0.28 to 0.29.

Remarks: Copper (1964) found Q. agglutinata species from Chuckchi sea at 13 to 19 m depth range. Braga and Galhano (1965) recorded it from Madeira Archipelago; and Haman (1971) obtained it as a rare species of foraminiferal assemblages in Tremadoc Bay, U. K.

From Indian region, Almeida and Setty (1972) obtained it from shelf region, near Vishakhapatnam, east coast of India in 55 to 123 m depth range.

Repository of type material: AMUGD Cat. No. MF 199.

Quinqueloculina bicarinata D'orbigny

Plate 2, figure 3

Quinqueloculina bicarinata D'ORBIGNY, 1826, p. 302.- BHATIA, 1955, p. 671, pl. 67, fig. 12 a-c.- HOFKER, 1968, p. 19, pl. 3, fig. 24-34.

Dimensions (in mm): Length 0.36 to 0.37, width 0.32 to 0.34, thickness 0.21 to 0.22.

Remarks: Bhatia (1955) found Q. bicarinata from late Palaeogene sediments of the Isle of Wight, England and Hofker (1968) recorded it from Jakarta Bay, Java. The known geological range of Q. bicarinata is from Oligocene to Recent.

Repository of type material: AMUGD cat. No. MF 200.

Quinqueloculina bicornis (Walker and Jacob)

Plate 1, figure 21

Serpula bicornis WALKER and JACOB, 1798, p. 633, pl. 14, fig. 2.

Miliolina bicornis WILLIAMSON, 1858, p. 87, pl. 7, fig. 190-194.- BRADY, 1884, p. 171, pl. 6, figs. 9, 11-12.

Quinqueloculina bicornis CUSHMAN, 1917, p. 48, pl. 13, fig. 2.- SETHULEKSHMI AMMA, 1958, p. 4, pl. 1, fig. 4.- ANTONY, 1968, p. 31, pl. 2, fig. 1.

Dimensions (in mm): Length 0.40 to 0.44, width 0.35 to 0.41, thickness 0.25 to 0.29.

Remarks: Q. bicornis is known from Pacific, North and East Atlantic, Mediterranean, and Arabian Sea. Norton (1930) found it from south of Key coast at 110 m depth and 20.6°C temperature. Cushman (1944) recorded this species from 24 m depth off Lamberts cove, Vineyard sound, U. S. A. Braga (1960) recorded it from Mozambique coast at 250 m depth; and at 90 to 100 m depth from Maderia Archipelago (Braga and Galhano, 1965). Haman (1971) found living specimens of Q. bicornis from shoal (depth 0 to 18 m, salinity 16.5 to 33.5 ‰) and shallow (depth 18 to 37 m, salinity 33.5 to 34.0 ‰) environment from Tremadoc bay.

From Indian waters, Sethulekshmi Amma (1958) recorded it from Travancore coast and Antony (1968) observed frequent to rare occurrence at 22 to 183 m depth range, also from the same coast.

Summary of Ecological data: Depth upto 183 m, temperature 20.6°C, salinity 16.5 to 34.0 ‰.

Repository of type material: AMUGD cat. No. MF 201.

Quinqueloculina hagni n. sp.

Plate 2, figure 8

Quinqueloculina sp. A. BHATIA AND KUMAR, 1976, pl. 2, fig. 7.

Description: Test of medium size, porcellaneous, imperforate, quinquline in plan, longer than broad, oval in side view, rounded in end view; chambers distinct tubular, enlarging rapidly as added; in four-chambered view, first chamber less exposed, sutures, simple, rather flush with surface, second chamber slightly raised, in three-chambered view, central chamber slightly visible, almost flush with surface, sutures slightly depressed; periphery, smooth, rounded, aperture terminal on a short neck, semicircular with lip, simple tooth, surface smooth, shining.

Dimensions (in mm):

	Holotype	Other specimens
Length	0.80	0.76 to 0.89
Width	0.42	0.41 to 0.43
Thickness	0.24	0.21 to 0.25

Illustrations, plate 2, figures 8a-c.

Variations: *Quinqueloculina hagni* n. sp. shows variation in shape and size of the test. Sutures are mostly flush with surface but sometimes may be little depressed.

Remarks: Bhatia and Kumar (1976) recorded an indeterminate species of Quinqueloculina Quinqueloculina sp. A- from the Recent sediments of Bingy Bay, Anjidiv Island, Karwar, west coast of India. This species is similar to Quinqueloculina hagni n. sp. and hence it is being included within the scope of this new species. Quinqueloculina hagni n. sp. also shows resemblance to Quinqueloculina procera (Silvestri) (= Quinqueloculina adelsonia procera Selvestri), but striations on test are absent in the present new species, sutures are flush, and edges of chambers are not as sharp as in Q. procera. This new species can be distinguished from Q. ludwigi Reuss, in having the greatest width of the test in the middle and the absence of necking near the junction of the last two chambers. As against Q. ludwigi, the neck is long in the present new species and the aperture is prominent with lip.

Type horizon: Recent beach sands.

Type locality: Ratnagiri beach, west coast of India.

Geological age: Recent

Repository of type material: AMUGD cat. No. MF 202.

Etymology: The present new species has been erected to honour Professor Dr. Herbert Hagn, Munich, for his monumental work on Foraminiferida.

Quinqueloculina kerimbatica (Heron-Allen and Earland)

Plate 2, figure 29

Miliolina kerimbatica HERON - ALLEN and EARLAND, 1915, p. 574, pl. 12, fig. 4.

Quinqueloculina kerimbatica CUSHMAN, 1921, p. 437, *HOFKER, 1968, pp. 18-19, pl. 3, figs. 8-22.- ZOBEL, 1973,* pl. 1, fig. 57.

Dimensions (in mm): Length 0.55 to 0.58, width 0.36 to 0.37, thickness 0.25 to 0.27.

Remarks: Hofker (1968) found Q. kerimbatica in Jakarta bay and discussed its taxonomy and associations in detail. Braga (1960) recorded it from Mozambique coast. Only Zobel (1973) reported this species from Indian region.

Repository of type material: AMUGD cat. No. MF 203.

<u>Quinqueloculina laevigata</u> D'orbigny

Plate 2, figure 14

<u>Quinqueloculina laevigata</u> D'ORBIGNY, 1839, p. 143, pl. 3, figs. 31-33.- RAO, VEDANTUM and RAO, 1979, p. 361.

<u>Dimensions (in mm)</u>: Length 0.38 to 0.39, width 0.14 to 0.15, thickness 0.13 to 0.14.

<u>Remarks</u>: <u>Q. laevigata</u> is a shallow water species and tolerates a wide range of salinity fluctuations. Said (1949) recorded it at 17 to 30 m depth from northern Red Sea and Braga (1960) reported it from coast of Mozambique. Phleger (1964) found living specimens of <u>Q. laevigata</u> from 10 to 20 m depth range from the Gulf of California. Sen Gupta and Schafer (1973) encountered it from Castries bay from 4 m depth at 26.4°C mean temperature, 34.7 ‰ mean salinity and 7.9 mean pH. Lankford and Phleger (1973) reported this species from the nearshore (6 to 33 m) turbulent zone, western North America. Resig (1974) obtained <u>Q. laevigata</u> in land locked Hawaiian lake and Brasier (1975) found living specimen from marsh, lagoon, mangrove creeks, and open marine environment from Barbuda region. Scott <u>et al</u>. (1976) found its living specimens from San Diego Bay at 24 to 50 m depth, 31 to 34 ‰ salinity ranges, from Agua Hedionada lagoon at 8 m depth and salinity ranges 32.5 to 34 ‰.

Rao *et al*. (1979) reported *Q. laevigata* from shelf region of Vishakhapatnam, east coast of India at 20 to 90 m depth range. Cherif and Flick (1974, pa 237) studied wall structure of *Q. laevigata* and showed "The group of *Q. laevigata* (D'orbigny) shows a smooth surface. In the observed specimens the outer layer is thin, covers the test incompletely (Plate 2, figure 2) and consist of rather quadratic calcite crystals (Plate 2, figure 3). It shows a structure similar to that of the "Mosaic" pattern described by Haake, (1971). The wrinkled, rather smooth internal layer of the chamber could be well observed in this group (Plate 2, figure 4 - 5)".

Summary of ecological data: Depth upto 90 m, temperature 26.5°C, salinity 15 to 34.7 ‰, pH 7.9.

Repository of type material: AMUGD cat. No. MF 204.

Quinqueloculina lamarkiana D'orbigny

Plate 2m figure 5

Quinqueloculina lamarkiana D'ORBIGNY, 1839, p. 189, pl. 11, figs. 14-15.- BHATIA, 1956, p. 17, pl. 2, fig. 10.- GANAPATI and SATYAVATI, 1958, p. 106, pl. 1, figs. 21-23.- GANAPATI and SAROJINI, 1959, p. 312.- ROCHA and UBALDO, 1964a, p. 410, pl. 1, figs. 3a-b; 1964b, p. 647, pl. 2, figs. 1-2.- RAO, 1970a, pp. 588-589, figs. 10a-b; 1971b, p. 157; 1974, pl. 1, fig. 13.- BHATIA and KUMAR, 1976, p. 242.

Dimensions (in mm): Length 0.32 to 0.34, width 0.34, thickness 0.21 to 0.22.

Remarks: Q. lamarkiana is a cosmopolitan species. Said (1949) recorded it from Red Sea and Gulf of Suez at 17 to 80 m depth range. Parker (1954, p. 497) found this species from north-eastern Gulf of Mexico and according to her "This species, as I have defined it in this area, may represent a "Species group" rather than a discrete species. There is great variation in the acuteness of the chamber angles and the extent to which they project. There is also variation in the length of the apertural neck". She found it at 150 m depth but a few, probably displaced specimens, were found at more than 1500 m depth. Todd and Bonniman (1957) obtained rare specimens of Q. lamarkiana from offshore zone (4 to 34 m) of Gulf of Paria which is characterized by soft, gray-blue to green mud in deeper parts. Phleger (1964) reported living specimens of Q. lamarkiana from 11 to 18 m depth from Gulf of California and it was reported by Matoba (1970) from Matsushima Bay, north-eastern Japan at 12.5 m depth. Surface water of this area was having 183 to 28.9°C temperature, 14.85 to 15.82 ‰ chlorinity, 7.81 to 8.25 pH, 2.62 to 7.22 cc/l dissolved oxygen, 0.251 to 4.00 mg/l nitrogen, 0.037 to 0.127 total phosphorus ranges, while bottom water showed 18.4 to 27.4°C temperature, 14.93 to 16.34 ‰ chlorinity, 7.85 to 8.20 pH, 4.84 to 7.14 cc/l dissolved oxygen, 0.280 to 0.890 mg/l total nitrogen, 0.016 to 0.062 ml/l total phosphorus ranges. Albani (1965) encountered its abundant occurrence from Durban Bay, South Africa. Recently, Scott et al. (1976) recorded living specimens at a depth of 30 m from San Diego Bay, California.

Q. lamarkiana has been described from east as well as west coast of India. From the east coast of India, Ganapati and Satyavati (1958) found this species at 22 to 99 m depth and 17.8 to 28.3°C temperature ranges; Ganapati and Sarojini (1959) from Vishakhapatnam coast in sand facies at 0 to 27 m depth range. From the west coast, Bhatia (1956), Rocha and Ubaldo (1964a,b) found this species from sandy beaches. Rao (1970a) reported it from Gulf of

Cambay at 21.9 m depth in muddy sand substrate; (Rao 1971b) from north-eastern part of Arabian sea at 11 m depth off Kutch where surface water had 21.95°C temperature and substrate was muddy; (Rao, 1974) from mouth of Mandovi and Zuari estuaries, Goa, at 4.0 to 8.5 m depth, 27.8 to 28.7°C temperature, 33.68 to 35.15 ‰ salinity, 0.68 to 0.78 µg/l Phosphate and 0.6° to 1.95 mg/g organic carbon ranges. Recently, Bhatia and Kumar (1976) encountered Q. lamarkiana from Anjidiv Island near Karwar at 5 to 13 m depth, 28.7 to 30.1°C temperature, 8.7 to 9.9 pH (bottom), 33.49 to 35.01 ‰ salinity, 4.01 to 4.92 ml/l dissolved oxygen.

Haake (1971, p. 189) studied wall structure of Q. lamarkiana and observed "The rhombohedron of Quinqueloculina eburnea are quite different from those on Q. lamarkiana and Q. carinata (fig. 5a and 5b). Their appearance suggests the term "mosaic" pattern. The crystal are not rectangular but more quadratic or rather equidimensional. They differ in size and the arrangement of crystal is somewhat irregular".

Summary of ecological data: Depth upto 150 m, temperature 18.3 to 30.1°C, salinity 28.6 to 35.15 ‰, pH 7.8 to 9.9, oxygen 2.6 to 7.2 ml/l (surface) and 4.01 to 7.4 ml/l.

Repository of type material: AMUGD cat. No. MF 205.

Qunqueloculina ludwigi Reuss

Plate 1, figure 20

Qunqueloculina ludwigi REUSS, 1866, p. 126, pl. 1, fig. 12.

Dimensions (in mm): Length 0.45 to 0.50, width 0.26 to 0.31, thickness 0.19 to 0.20.

Remarks: Reuss (1866) reported for the first time Q. ludwigi from the Oligocene of Germany. Batjas (1958) p. 103, pl. 1, fig. 14) found it from the Oligocene of Belgium and observed "All quinqueloculina seminula like individuals from the Boom clay have more or less extended apertural neck. Apart from the less depressed suture they resemble fairly well Reuss's Q. ludwigi, ". Kaasschicter (1961) recovered it in abundance from the Eocene of Belgium. Recently, Cherif (1973) recorded 12% occurrence from Recent sediment from Aegean Sea, Greece. During the study of wall structure Cherif and Flick (1974, p. 231), included this species as a member of group of Q. disparilis D'orbigny and observed "The group of Q. disparilis D'orbigny has a thin, particularly smooth outer veneer consisting of crystal showing a "parqut" pattern in some places".

Repository of type material: AMUGD cal. No. MF 206.

<u>Quinqueloculina</u> <u>mediterranensis</u> Le Calvez

Plate 3, figure 4

<u>Quinqueloculina</u> <u>mediterranensis</u> LE CALVEZ, 1958a, p. 177, pl. 4, figs. 29 - 31.

<u>Miliolina</u> <u>bicernis</u> SIDE BOTTOM (<u>non</u> Walker & Jacob), 1904, pl. 4, figs. 13-14.

<u>Dimensions (in mm)</u>: Length 0.67 to 0.69, width 0.34 to 0.35, thickness 0.21 to 0.22.

<u>Remarks</u>: Le Calvez (1958a) described <u>Q.</u> <u>mediterranensis</u> for the first time from Villefranche. Atkinson (1971) recorded only empty tests of this species at 9 stations from littoral zone down to 26 m depth from Cardigan Bay, U. K.

<u>Repository of type material</u>: AMUGD cat. No. MF 207

Quinqueloculina oblonga (Montagu)

Plate 2, figure 12

Vermiculum oblonga MONTAGU, 1803, p. 522, pl. 4, fig. 9.

Quinqueloculina oblonga HOFKER, 1971, p. 14.

Dimensions (in mm): Length 0.60 to 0.62, width 0.30 to 0.40, thickness 0.18 to 0.19.

Remarks: Hofker (1971) recorded this species from narrow entrance as well as in the inner bay, mostly in the muddy environment from the Piscadera Bay, Curacao.

Repository of type material: AMUGD cat. No. MF 208.

Quinqueloculina parkeri (Brady)

Plate 2, figure 13

Miliolina parkeri BRADY, 1881, p. 46; 1884, p. 177, pl. 7, fig. 14.

Quinqueloculina parkeri (Brady) CUSHMAN, 1917, p. 50, pl. 15, fig. 3.- GUPTHA, 1973a, p. 2.- SEIBOLD, 1975, p. 182, pl. 1, fig. 6.- REDDY and RAO, 1980, p. 164, pl. 2, figs. 1-3.

Dimensions: Length 0.31 to 0.33, width 0.29 to 0.30, thickness 0.19 to 0.20.

Remarks: Morton (1930) recorded Q. parkeri from Murray island at 0.5 m depth and 23.0 to 28.8°C temperature range and also from 5 km east of Andros Island at 1530 m depth and 4°C temperature. Uchio (1962) reported this species from Nishihiro, Seto, Kushimoto beaches and also at 2.9 to 8.6 m depth from Mori Harbour along the coast of Wakayama-kon, Japan. Betjeman (1969) recorded Q. parkeri from the Western Australian continental shelf and considered it as tropical to sub-tropical species. It was reported by Sen Gupta and Schafer (1973) from Castrics Bay as a rare species at 15 m depth with sandy substrate, 26.4°C mean temperature, 34.7 ‰ mean salinity, and mean pH 7.9. Brasier (1975) reported less than 1% occurrence of Q. parkeri from inter-reef (5 to 10 m depth) and upto 5% in fore-reef (20 to 150 m depth) environment of Barbuda region, West Indies.

From Indian region, Guptha (1973a) observed it from Kavaratti atoll at 2 m depth, 30.6 to 32.5°C temperature (bottom) and 33 to 53 ‰ salinity ranges. Seibold (1975) recorded rare occurrence of Q. parkeri from coast of Cochin. Recently, Reddy and Rao (1980) reported it from Pennar estuary, Andhra Pradesh.

Summary of ecological data: Depth upto 150 m (1500 m) temperature 4.0 to 32.5°C, salinity 33 to 53 ‰, and pH 7.9.

Repository of type material: AMUGD cat. No. MF 209.

Quinqueloculina phoenica Colom

Plate 3, figure 1.

Quinqueloculina phoenica COLOM, (*non* Martinotti), 1942, p. 18, pl. 4, fig. 72-74.

Dimensions (in mm): Length 0.39 to 0.41, width 0.26 to 0.28, thickness 0.11 to 0.12.

Remarks: Le Calvez reported *Q. phoenica* from bay of Villefranche at 10 to 70 m depth and our specimens closely resemble to figures given by her (Le Calvez, 1958a, p. 178, pl. 4, figs. 24-25).

Repository of type Material: AMUGD cat. No. MF 210.

Quinqueloculina polygona D'orbigny

Plate 3, figure 2.

Quinqueloculina polygona D'ORBIGNY, 1839, p. 98, pl. 12, fig. 21-23.

Dimensions (in mm): Length 0.44 to 0.47, width 0.21 to 0.23, thickness 0.17 to 0.18.

Remarks: Norton (1930) recorded Q. polygona from beach and offshore regions of Florida and West Indies and also from Murray Island, Australia. Parker (1954) reported rare occurrence of this species from north-eastern Gulf of Mexico, consistently at a depth of 100 m and scattered up to 185 m. Agustin (1963) found it from lagoon of Ferminos, Camplechei, Mexico at 29.0°C to 31.0°C temperature range having 14.5 ‰ salinity. Hofker (1964, 1969, 1971) observed the occurrence of Q. polygona from tidal zone of Netherlands, Antilles and other west Indian Islands, from shallow and deep waters of Barbudos, from Piscardera Bay, Luracao, at 3 to 4 m depth range with sandy substrate. Sengupta and Schafer (1973) recorded rare occurrence of Q. polygona from Chock Bay of St. Lucia, West Indies, at 13 m depth having sandy substrate, 25.8°C mean temperature 35.8‰ mean salinity and 8.2 mean pH.Seiglie (1974) found only dead specimens of this species from

Mayaguez Bays, off the central western coast of Puerto Rico and its surroundings, in 24 to 29°C temperature and 33.3 to 36.8 ‰ salinity ranges. Brasier (1975) recorded less than 1% of its occurrence in reef environment (1 to 150 m depth) from Barbuda.

Summary of ecological data: Depth upto 100 m (185), temperature 24.0 to 31.0°C, salinity 14.5 to 36.8 ‰, pH 8.2.

Repository of type material: AMUCD cat. No. MF 211.

Quinqueloculina pseudoreticulata Parr

Plate 2, figure 1.

Quinqueloculina pseudoreticulata PARR, 1941, p. 177, pl. 9, figs. 2-3.- BARKAR, 1960, p. 18, pl. 9, figs. 2-3.- ROCHA and UBALDO, 1964a, p. 6, pl. 1, figs. 4a-b, 1964b, p. 647, pl. 2, figs. 3-4.

Dimensions (in mm): Length 0.66 to 0.67, width 0.53 to 0.54, thickness 0.38 to 0.39.

Remarks: This tropical and sub-tropical, shallow water species of Quinqueloculina was originally described by Parr (1941) from South Australia. Rocha and Ubaldo (1964a-b) reported it from Jampore and Baga beaches from west coast of India.

Repository of type material: AMUGD cat. No. MF 212.

Quinqueloculina rugosa D'orbigny

Plate 2, figure 4.

Quinqueloculina rugosa D'ORBIGNY, 1826, SCHLUMBERGER, 1893, p. 240, pl. 4, fig. 91-92.

Miliolina rugosa WIESNER 1923, p. 46, pl. 6, fig. 54.

Dimensions (in mm): Length 0.70 to 0.73, width 0.36 to 0.38, thickness 0.20 to 0.24.

Remarks: Our specimen closely resemble to those described by Le Calvez (1958a) from bay of Villefranche. *Q. rugosa* differs from *Q. polygona* by the position of greatest width and ornamentation.

Repository of type material: AMUGD cat. No. MF 213.

Quinqueloculina *cf*. *Q*. *schlumbergeri* (Wiesner)

Plate 1, figure 22.

Miliolina schlumbergeri WIESNER, 1923, p. 49, pl. 6, fig. 73.

Quinqueloculina schumbergeri (Wiesner) HAAKE, 1970, p. 196, pl. 23, figs. 3-4.- RAO, VEDANTUM and RAO, 1979, p. 361.

Dimensions (in mm): Length 0.61 to 0.63, width 0.30 to 0.32, thickness 0.23 to 0.24.

Remarks: Our specimens are comparable with *Q*. *schumbergeri* (Wiesner) as figured and described by Haake (1975, pl. 1, fig. 19) from Persian Gulf. However, specimens in the present assemblage show some difference in four-chambered view and length of the test. This species was reported by Rao *et al*. (1979) from Vishakhapatnam shelf, east coast of India at 20 to 90 m depth range.

Repository of type material: AMUGD cat. No. MF 214.

<u>Quinqueloculina</u> <u>seminulum</u> (Linné)

Plate 1, figure 18.

<u>Quinqueloculina</u> <u>seminulum</u> LINNÉ, 1758, p. 786.

<u>Miliolina</u> <u>seminulum</u> WILLIAMSON, 1858, p. 85, pl. 7, figs. 183-185.- BRADY, 1884, p. 157, pl. 5, figs. 6a-c.

<u>Quinqueloculina</u> <u>seminulum</u> (LINNÉ) D'ORBIGNY, 1826, p. 303.- GNANAMUTHU, 1943, p. 10, pl. 2, figs. 4 a-b.- BHATIA, 1956, p. 17, pl. 2, fig. 9.- BHATIA and BHALLA 1964, p. 79, p. 1. figs. 1a-b.- ANTONY, 1968, p. 30, pl. 1, fig. 23.- BHALLA, 1968, pp. 380-381, pl. 1, figs. 1a-b; 1970, pp. 156-157, pl. 20, figs. 1a-b.- RAO, 1970a, p. 589, figs. 12a-b; 1971b, p. 157.- RAO and RAO, 1974, pl. 1, fig. 11.- BHATIA and KUMAR, 1976, p. 242 (table).- REDDY and RAO, 1980, p. 164, pl. 2, figs. 4-6.

<u>Dimensions (in mm)</u>: Length 0.59 to 0.61, width 0.36 to 0.39, thickness 0.30 to 0.32.

<u>Remarks</u>: <u>Q. seminulum</u> is a well known but highly confused species of <u>Quinqueloculina</u>. Different authors have described it under different names and a long synonymy bears a testimony to it. It is very difficult to give an adequate synonymy and an exact distribution. <u>Q. seminulum</u> is a cosmopolitan species and tolerates a wide range of

salinity and temperature fluctuations. Norton (1930) recorded this species from Florida and West Indies region at 0 to 2849 m depth and 1.83 to 31.4°C temperature ranges. Cushman (1944) reported it from beaches of Maine, New Hampshire, Massachusetts and Rhode Island. Todd and Bronnimann (1957) found it as a member of near-shore (0 to 4 m) and offshore (4 to 34 m) zones from Eastern Gulf of Paria, Trinidad, at surface temperature 27 to 29°C, bottom temperature 27°C, chlorinity 17 to 19.4 ‰ (surface) and 18 to 19.4 ‰ (bottom) and salinity 30 to 35.0 ‰ (surface) and 32.5 to 35.0 ‰ (bottom) ranges. Todd and Low (1961) recorded abundant specimens of Q. seminulum from open sea beaches facing Atlantic ocean (temperature 19 to 23°C and salinity 31.1 to 32.1 ‰), Vineyard Sound (temperature 20 to 24°C and salinity 31.1 to 31.6 ‰) and Nantucket Sound (temperature 20 to 24°C and salinity 30.6 to 32.4 ‰); however, rare specimens were present at other stations. It occurs frequently in near-shore waters and Kane (1967) recorded it from estuarine to truly marine conditions. Sen Gupta and Schafer (1973) recorded this species at all the stations from Castries Bay (depth 3 to 17 m, mean temperature 26.4°C, salinity 34.7 ‰, pH 7.9); and at few stations from Choc Bay (depth 5 to 13 m, mean temperature 25.8°C, salinity 35.8 ‰ and pH 8.2). Sen Gupta (1977) observed that Q. seminulum is a characteristic species of inner and middle shelf. Recently, Poag (1980) encountered Q. seminulum from outer continental shelf of New Jersey, where substrate is quartzose sand and salinity ranges from 33.60 to 33.7 ‰ and dissolved oxygen varies from 7.1 ppm to 7.5 ppm.

Gnanamuthu (1943), Bhatia and Bhalla (1964), Bhalla (1966, 1970), Rao and Rao (1974), Reddy and Rao (1980) reported this species from east coast of India, while Bhatia (1956), Antony (1968), Rao (1970a, 1971b). Bhatia and Kumar (1976) have recorded it from the west coast of India.

The known geological range of this species is from Eocene to Recent.

Summary of ecological data: Depth upto 2894 m, temperature 1.83 to 31.4°C, salinity 30 to 35.8 ‰, pH 7.9 to 8.2.

Repository of type material: AMUCD cat. No. MF 215.

Quinqueloculina singhi n. sp.

Plate 2, figure 11

Description: Test of medium size, porcellaneous, imperforate, quinqueloculine in plan, rounded in side view, oval in end view; chambers distinct, tubuler, enlarging rapidly as added; in four-chambered view, first chamber very little exposed, second chamber raised, suture simple, very slightly depressed; in three-chambered view, central chamber little exposed, suture distinct, slightly depressed, periphery broadly rounded; aperture rounded with definite well exposed bifid tooth, surface smooth but faint striations present in three-chambered view near the junction of last two chambers.

Dimensions (in mm):

	Holotype	Other specimens
Length	0.57	0.56 to 0.58
Width	0.53	0.50 to 0.54
Thickness	0.37	0.36 to 0.38

Illustrations: Plate 2, figure 11a-c.

Variations: Quinquloculina singhi n. sp. does not show much variation except in the size and degree of test inflation. Striations at the junction of last two chambers are prominant in some specimens and less in others.

Remarks: Quinqueloculina singhi n. sp. shows some resemblence to Quinqueloculina subdecorata Cushman in traces of costae near the margin, but differs in the shape of the test and nature of aperture. While this new species shows a definite rounded aperture with bifid tooth, Q. subdecorata shows a semicircular aperture.

Type horizon: Recent beach sands.

Type localities: Ratnagiri beach sand; also in Chapora, Anjuna and Calangute beaches along the west coast of India.

Geological age: Recent.

Repository of type material: AMUGD cat. No. MF 216.

Etymology: This new species is being named in honour of Late Professor S. N. Singh, University of Lucknow, in recognition of his significant contributions to the micropaleontology of India.

Quinqueloculina undulosa costata Terquem

Plate 2, figure 6

Quinqueloculina undulosa costata TERQUEM, 1882, p. 185, pl. 20, figs. 18-19.- BHATIA, 1956, p. 17, pl. 2, fig. 8.- ROCHA and UBALDO, 1964a, p. 412, pl. 1, figs. 5a-b.- BHATIA and KUMAR, 1976, p. 242.- REDDY and RAO, 1980, p. 164, pl. 2, figs. 7-9.

Dimensions (in mm): Length 0.5 to 0.7, width 0.36 to 0.37, thickness 0.27 to 0.28.

Remarks: Terquem (1882) described holotype of *Q. undulosa costata* from the Eocene of Paris Basin. From Indian waters, Bhatia (1956) reported it from Juhu and Chowpatty beaches, Bombay, and Bhogat beach, Gujarat. Rocha and Ubaldo (1964a) found it from Diu, Gogola and Simbor beaches. Bhatia and Kumar (1976) recorded 1% occurrence of *Q. undulosa costata* from Anjidiv Island near Karwar from 8.5 to 10 m depth and 28.7 to 29.8°C temperature, 9.5 pH (bottom), 34.72‰ salinity and 4.23 to 4.31 ml/l dissolved oxygen ranges. Recently, Reddy and Rao (1980) reported it from Pennar estuary, Andhra Pradesh, east coast of India.

Repository of type material: AMUGD cat. No. MF 217.

Quinqueloculina venusta Karrer

Plate 2, figure 10

Quinqueloculina venusta KARRER, 1868, p. 147, pl. 2, fig. 6.- CUSHMAN, 1916, p. 45, pl. 11, fig. 1.- BHATIA, 1956, p. 17, pl. 2, fig. 6.- RAO, 1971 b, p. 157, fig. 12.

Dimensions (in mm): Length 0.60 to 0.62, width 0.32 to 0.39, thickness 0.20 to 0.21.

Remarks: Our specimen is very similar to the one figures by Barkar (1960, pl. 1, fig. 5), which was originally referred to Miliolina venusta by Brady (1884) and described as essentially deep water species. Q. venusta has been reported by Norton (1930) from Bird Key Harbour (depth 50 m, temperature range 22.6 to 24.8°C); East of Andros Island at depth 1426 m, temperature 4°C. Parker (1954) showed that this species occurs at 1700 m depth and frequencies are less than one per cent (except for one occurrence of two per cent at 3164 m from NE gulf of Mexico). Lohmann (1978) reported this species from west-south Atlantic Ocean at 2272 m depth, 3.64°C temperature, 34.913 ‰ salinity when he was studying abyssal benthonic foraminifers as hydrographic indicators. More recently, Corlis (1979) reported it from South East Indian Ocean at a depth range of 3000 to 4600 m.

Q. venusta has been reported by Bhatia (1956) from Juhu and Bhogat beaches and Rao (1971b) reported it from the northern part of Arabian Sea near Kutch at a depth of 16 m. The known geological range of this species is from Cretaceous to Recent.

Summary of ecological data: Depth upto 4660 m, temperature 1.83 to 24.8°C and salinity 34.913 ‰.

Repository of type material: AMUGD cat. No. MF 218.

Quinqueloculina aff. *Q. viennensis* Le Calvez

Plate 2, figure 7

Quinqueloculina viennensis LE CALVEZ, 1958a
p. 187, pl. 5, figs. 42, 44, 45.

Quinqueloculina covieriana BRADY (non D'orbigny)
1884, Vol. 9, pl. 5, fig. 12.

Dimensions (in mm): Length 0.66 to 0.71, width 0.60 to 0.62, thickness 0.37 to 0.38.

Remarks: *Q. viennensis* has smooth, nearly rounded or oval, test and sutures are almost flush with surface. Our specimens resemble *Q. viennensis*, as figured and described by Le Calvez (1958a, pl. 5, fig. 44-45) from bay of Villefranche.

Repository of type material: AMUGD cat. No. MF 219.

Quinqueloculina vulgaris D'orbigny

Plate 1, figure 19

Quinqueloculina vulgaria D'ORBIGNY, 1826, p. 302.- SETHULEKSHMI AMMA, 1958, pp. 4-5, pl. 1, fig. 5.- GANAPATI and SATYAVATI, 1958, pl. 1, figs. 24, 26.- ROCHA and UBALDO, 1964a, p. 412, pl. 1, figs. 6a-b.- ANTONY, 1968, p. 29, pl. 1, fig. 22.- BHALLA, 1970, p. 157, pl. 20, figs. 3a-b.- RAO, 1970a, p. 589, figs. 11a-b, 1971b, p. 157.

Dimensions (in mm): Length 0.40 to 0.60, width 0.29 to 0.49, thickness 0.24 to 0.32.

Remarks: Q. vulgaris is a cosmopolitan species and has been recorded from both cold and warm waters at various depths ranging from beach to several metres. Norton (1930) observed Q. cf. Q. vulgaris from Florida at 15 to 100 m depth and 20.6 to 24.7°C temperature range. Said (1949) recorded it as widely distributed species in many shallow and mid depth areas (5 to 64 m) in Gulf of Suez and the Red Sea. Lankford and Phleger (1973) recorded Q. vulgaris at 0 to 30 m depth in preferably rocky bottom from near-shore turbulent zone west-north America. Sen Gupta and Schafer (1973) found it from Castries Bay (4 to 17 m depth, 26.4°C mean temperature, 34.7 ‰ salinity 7.9 pH) and in Choc Bay (15 m depth).

From east coast of India, Ganapati and Satyavati (1958) recorded _Q. vulgaris_ from 22 to 218 m depth and 21.9 to 26.7°C temperature range from Madras shelf; Bhalla (1970) from Marina beach sand and Rao _et al._ (1979) from shelf off Vishakhapatnam while from the west coast _Q. vulgaris_ was recorded by Sethulekshmi Amma (1953) from Travancore Coast; Rocha and Ubaldo (1964a) from Diu, Gogola and Sinbor beaches; Antony (1968) from Kerala Coast; and Rao (1970a) from gulf of Cambay and (1971b) from north-eastern part of Arabian Sea.

Summary of ecological data: Depth upto 218 m, temperature 20 to 26.7°C, salinity 34.7 ‰, pH 7.9.

Repository of type Material: AMUGD cat. No. MF 220

Quinqueloculina tropicalis Cushman

Plate 1, figure 17.

Miliolina gracilis (D'orbigny) BRADY, 1884, pl. 5, fig. 3.

Quinqueloculina tropicalis CUSHMAN, 1924, p. 63.– BHATIA and BHALIA, 1964, p. 78, pl. 1, figs. 2a-b.– BHALLA, 1968, p. 381, pl. 1, figs. 4a-b.

Dimensions (in mm): Length 0.317, width 0.15, thickness 0.1.

Remarks: *Q. tropicalis* is a characteristic Indo-Pacific species. Brady (1884) recorded it (= *Miliolina gracilis*) off Papua in the Pacific at a depth of 108 m. Later, Barker (1960) in his taxonomic comments on Brady's figure changed it to *Q. tropicalis*. Seiglie (1974) encountered rare occurrence of dead specimens of *Q. tropicalis* from Mayagüez Bay, off central west of Puerto Rico.

From Indian region, Bhatia and Bhalla (1964) reported it from Puri beach sand and Bhalla (1968) from Vishakhapatnam beach, east coast of India.

Repository of type material: AMUGD cat. No. MF 221.

<u>Quinqueloculina</u> Sp. <u>A</u>

Plate 1, figure 16

<u>Dimension (in mm)</u>: Length 0.25, width 0.23, thickness 0.18.

<u>Remarks</u>: A few specimens of Quinqueloculina could not be identified and are, therefore, put here in open nomenclature as <u>Quinqueloculina</u> Sp. <u>A</u>.

Our specimens are similar to "young miliolid" of Brady (1884, pl. 3, fig. 12). They also show some affinity with <u>Q. longrirostra</u> D'orbigny but are rounded in shape and sutures are not prominent. More specimens are required for correct identification.

<u>Repository of type material</u>: AMUGD cat. No. MF 222.

Quinqueloculina sp. B.

Plate 2, figure 9.

Dimensions (in mm): Length 0.69, width 0.48, thickness 0.27.

Remarks: Quinqueloculina sp. B. somewhat resembles Q. venusta Karrer but differs in shape and development of the last chamber. It also shows some affinity to Q. lamarkiana D'orbigny in apertural view but differs in side view. From Q. seminulangulata McLean, the present species differs in not having sharp edges. However, Quinqueloculina sp. B differ from Quinqueloculina sp. A in having sharp margined, oval and large test with triangular periphery in apertural view.

Repository of type material: AMUGD cat. No. MF 223.

Genus TRILOCULINA D'orbigny, 1826.

Triloculina insignis (Brady).

Plate 3, figure 13.

Miliolina insignis BRADY, 1884, p. 165, pl. 4, figs. 8-10.

Triloculina insignis CUSHMAN, 1917, p. 64, pl. 17, figs. 3a-b.- SETHULEKSHMI AMMA, 1958, p. 8, pl. 1, figs. 14a-b.- ANTONY, 1968, pp. 37-38, pl. 2, figs 12a-b.

Dimensions (in mm): Length 0.32 to 0.34 width 0.30 to 0.31, thickness 0.21 to 0.22.

Remarks: Brady (1884) reported T. insignis (= Miliolina insignis) at 714 m from West Indies and from Pacific at 70 to 73 m depth. Later, Barker (1960) summarized views of different authors on the validity of Brady's identification and concluded that fig. 8 on plate 4 of Brady's report belongs to Triloculina insignis. Norton (1930) recorded this species from Tortugas, Florida at 15 m depth and 22.6 to 27.7°C temperature range.

From the east coast of India, Sethulekshmi Amma (1958) reported rare occurrence of T. insignis from Trivandrum and Vizhinjam at 20 to 22 m depth and Antony (1968) encountered its rare occurrence from Cochin coast at 27 to 183 m depth range.

Summary of ecological data: Depth upto 714 m, temperature 22.6 to 27.7°C.

Repository of type material: AMUGD cat. No. MF 224.

Triloculina aff. *T. echinata* D'orbigny

Plate 3, figure 5.

Triloculina echinata D'ORBIGNY, 1926, p. 1391, Sr. 300 Nr. 14.- RAO, VEDANTAM and RAO, 1979, p. 359.

Dimensions (in mm): Length 0.38, width 0.33, thickness 0.23.

Remarks: Spinose ornamentation, which is characteristic of *T. echinata* is less prominent in our specimens and neck is also short. Less prominent spinose ornamentation may be due to abrasion. Rao *et al.* (1979) recorded its continuous distribution in 20 to 90 m depth zone and erratic distribution in 90 to 190 m depth zone from Vishakhapatnam shelf, east coast of India.

Repository of type material: AMUGD cat. No. MF 225.

Triloculina laevigata D'orbigny.

Plate 3, figure 7.

Triloculina laevigata D'ORBIGNY, 1826, p. 300, no. 15.- GNANAMUTHU, 1943, p. 5, pl. 2, fig. 13.- ANTONY, 1968, p. 39, pl. 1, figs. 14a-b.

Dimensions (in mm): Length 0.66 to 0.67, width 0.23 to 0.25, thickness 0.23.

Remarks: Said (1949) found T. laevigata in small numbers from Gulf of Suez at 59 to 64 m depth and Braga and Galhano (1965) encountered it from Maderira Archipelago at 80 to 950 m depth range. From the east coast of India, T. laevingta was reported by Gnanamuthu (1943) from Krusadi Island. Antony (1968) recovered it from Quilon, Alleppy and Cochin sections of Kerala coast at 92 to 183 m depth range.

Depth range: upto 950 m.

Repository of type material: AMUGD cat. No. MF 226.

Triloculina oblonga (Montagu)

Plate 3, figure 9.

Vermiculum oblongum MONTAGU, 1803, p. 522, pl. 14, fig. 9.

Miliolina oblonga BRADY, 1884, p. 160, pl. 5, fig. 4.

Triloculina oblonga D'ORBIGNY, 1826, p. 300., JETHULEKSHMI AMMA, 1958, p. 6, pl. 1, fig. 9.– ANTONY, 1968, p. 39, pl. 2, fig. 15.– RAO, 1970a, p. 593, figs. 24a–b; 1971b, p. 157; 1974, pl. 1, fig. 18.– RAO and RAO, 1974, pl. 1, figs. 13a–b.– RAO, VEDANTAM and RAO, 1979, p. 359.

Dimensions (in mm): Length 0.32 to 0.35, width 0.17 to 0.19, thickness 0.13 to 0.14.

Remarks: Norton (1930) recorded *T. oblonga* from beach to 5194 m depth from Florida and West Indian region. Cushman (1944) found a single specimen in blue clay at a depth of 73 m from New England Coast. Said (1949) recorded slightly keeled specimens at 92 to 400 m depth from the Red Sea. Todd and Brönnimann (1957) showed its rare occurrence from offshore zone (4 to 23 m) and common occurrence from nearshore region (0 to 4 m) of eastern Gulf of Paria.

Schafer and Sen Gupta (1968) found it in living condition (more than 5%) from Castries Bay, St. Lucia, in mean salinity 35.8 ‰, temperature 25.8°C and pH 8.2. Recently, Lagoe (1977) found it in 1181 to 2732 m depth range from Central Arctic Ocean.

From the Indian region, T. oblonga was recorded by Antony (1968) from Kerala Coast at 23 to 183m depth range; Rao (1970a) from Gulf of Cambay at 21.9 m depth with muddy sand substrate; Rao (1971b) from north-eastern part of the Arabian Sea from 14 to 64 m depth; Rao (1974) from the mouth of Mandovi river at 8.5 m depth, 27.8°C temperature, 33.68 ‰ salinity, 0.58 µg/l phosphate and 0.60 mg/g organic carbon. Rao and Rao (1974) encountered rare occurrence of T. oblonga from Suddagedda estuary, east coast of India, at 28.35 ‰ salinity, 24°C temperature 2.46 ml/l dissolved oxygen with sandy substrate, 0.10 to 0.13 % organic matter, while Rao et al. (1979) found it continuously within 20 to 90 m and erratically within 90 to 190 m depth ranges from Visakhapatnam shelf, east coast of India.

Summary of ecological data: Depth upto 5194 m, temperature 24.0 to 27.8°C, salinity 28.35 to 35.8 ‰, pH 8.2.

Repository of type material: AMUGD cat. No. MF 227.

Triloculina gasimi n. sp.

Plate 3, figure 14.

Description: Test of small size, porcellaneous, imperforate, triloculine in plan, oval in side view, sub-rounded in end view; in three chambered views, first chamber raised, slightly oblique, chambers increasing gradually; sutures, simple, depressed; periphery subrounded, smooth; aperture broad with bifid tooth; surface smooth.

Dimensions (in mm):

	Holotype	Other specimens
Length	0.32	0.3 to 0.4
Width	0.29	0.25 to 0.29
Thickness	0.20	0.19 to 0.22

Illustration plate 3, figures 14a-c.

Variations: Variation exists in the shape and size of the test and the degree of inflation of second chamber.

Remarks: *T. gasimi* n. sp. is very similar to *Triloculina asymmetrica* (Said, 1949, p. 18, pl. 2, fig. 11) in overall shape but former is half of the later in size. In three chambered view first chamber is fairly visible in both but, it covers one third of the total width of test in *T. gasimi* whereas in *T. asymetrica*, it covers half of the width.

Type Horizon: Recent beach sand.

Type localities: Juhu and Karwar beaches, west coast of India.

Geological age: Recent.

Repository of type material: AMUGD cat. No. MF 228.

Etymology: This new species has been named in honour of Dr. S. Z. Qasim, Ex Director, National Institute of Oceanography, Goa, and Secretary, Department of Environment for his constant encouragement and magnificient co-operation during the course of the present work.

<u>Triloculina rotunda</u> D'orbigny

Plate 3, figure 12

<u>Triloculina rotunda</u> D'ORBIGNY, 1826, p. 229, no. 4.- BHATIA, 1956, p. 18, pl. 2, fig. 1.

<u>Dimensions (in mm)</u>: Length 0.4 to 0.42, width 0.4 to 0.42, thickness 0.29 to 0.30.

<u>Remarks</u>: Norton (1930) observed a marked tendency in <u>T. rotunda</u> to live in shallow water (beach to 15 m) at 21.5 to 31.9°C temperature range, but is not confined to these depths. This species has been reported by Matoba (1970) from Matushima Bay, Northeast Japan, in outer bay facies at 4.4 to 12.5 m depth. Brasier (1975) found it from lagoon and open marine environment of Barbuda, but it is more common in Mangrove creeks at 26.0 to 29.0°C temperature and 34 to 36 ‰ salinity ranges. Lagoe (1977) recovered <u>T. rotunda</u> from Arctic ocean at a depth of 1567 to 2653 m.

Bhatia (1956) found frequent to rare occurrence of <u>T. rotunda</u> from Juhu and Bhogat beaches of the west coast of India.

<u>Summary of ecological data</u>: Depth upto 15 m (1567 to 2653 m in Artic ocean), temperature 21.5 to 31.5°C, and salinity 34.0 to 36.0 ‰.

<u>Repository of type material</u>: AMUGD cat. No. MF 229.

Triloculina rupertiana (Brady)

Plate 3, figure 8.

Miliolina rupertiana BRADY, 1884, pl. 7, fig. 7-12.

Triloculina rupertiana (Brady) CUSHMAN, 1921, p. 464, pl. 93, fig. 2.- BHATIA, 1956, p. 19, pl. 2, fig. 4.- GANAPATI and SATYAVATI, 1958, pl. 2, fig. 40.- BHATIA and KUMAR, 1976, Table 2.- RAO et al. VEDANTUM and RAO, 1979, p. 361.

Dimensions (in mm): Length 0.81 to 0.92, width 0.41 to 0.43, thickness 0.20 to 0.22.

Remarks: Brady (1884) originally described T. rupertiana (=Miliolina rupertiana) from New Guinea, Torres Strait, Papua stations of Pacific at 11 to 51 m depth range. It was reported from the west coast of India by Bhatia (1956) from Juhu beach sand, Bombay; Bhatia and Kumar (1976) from near Anjidiv, Karwar, at 6.5 m depth, 29.0°C temperature, 9.3 pH, 33.49 ‰ salinity, 4.92 ml/l dissolved oxygen. From the east coast of India, Ganapati and Satyavati (1958) recorded it from 18 to 81 m depth and 25.0 to 26.7°C temperature ranges. Recently, Rao et al. (1979) found it from Vishakhapatnam shelf at less than 35 m depth.

Summary of ecological data: Depth upto 81 m, temperature 25.0 to 29.0°C and salinity 33.49 ‰, pH 9.3.

Repository of type material: AMUGD cat. No. MF 230.

Triloculina terquemiana (Brady)

Plate 3, figure 10.

Miliolina terquemiana BRADY, 1884, p. 166, pl. 114, figs. 1a-b.

Triloculina terquemiana (BRADY) CUSHMAN, 1916, p. 72, pl. 27, fig. 2.- BHATIA, 1936, pl. 2, fig. 3.- SESHULEKSHMI AMMA, 1958, p. 9, pl. 1, figs. 15a-b.- ROCHA and UBALDO, 1964a, p. 413, pl. 2. fig. 5.- BHALLA, 1968, p. 381, pl. 1, figs. 5a-b.- RAO, 1971b, p. 157, fig. 15.

Dimensions (in mm): Length 0.42 to 0.46, width 0.34 to 0.35.

Remarks: Triloculina terquemiana was reported by Brady (1884) from Madagascar shore sands and shallow water sounds from Ceylon. This species is also known from Mozambique and Hong Kong Harbour. Norton (1930) found rare specimens of T. terquemiana from Tortugas, Florida, at 15 m depth and 22.6 to 24.7°C temperature range. Matoba (1970) found this species at 2.2 to 12.5 m depth from Matsushima Bay, North-East Japan as member of outer bay facies.

From the west coast of India, T. terquemiana has been reported by Bhatia (1956) from shore sands of Bombay, Rocha and Ubaldo (1964a), from Baga beach, Goa; Rao (1971b) from north-eastern part of the Arabian Sea and Bethulekshmi Amma (1958) from Travancore coast. From the east coast of India this species was recorded by Bhalla (1968) from beach sand of Vishakhapatnam and Rao et al. (1979) from shelf region off Vishakhapatnam at 106 m depth in sandy substrate.

Summary of ecological data: Depth upto 106 m, temperature 22.6 to 24.7°C.

Repository of type material: AMUCD cat. No. MF 231.

Triloculina tricarinata D'orbigny

Plate 3, figure 6.

Triloculina tricarinata D'ORBIGNY 1826, p. 299, no. 7, model no. 94.- BHATIA, 1956, p. 19, pl. 1, fig. 16.- SETHULEKSHMI AMMA 1958, p. 8, pl. 1, fig. 12.- ROCHA and UBALDO, 1964a, p. 413, pl. 2, figs. 6a-b, 1964b, p. 647, pl. 2, figs. 11-12.- BHALLA, 1968, pp. 381-382. pl. 1. figs. 3a-b.- ANTONY, 1968, p. 38, pl. 2. figs. 13a-b.- RAO, 1970a, pp. 592-593, pl. 3, fig. 22.- SEIBOLD, 1975, p. 182.- BHATIA and KUMAR, 1976, p. 242 (table).

Dimensions (in mm): Length 0.42 to 0.51, width 0.26 to 0.33.

Remarks: Norton (1930) recorded rare specimens of T. tricarinata from several Islands of Australia (at a depth of 0.5 m, temperature 23° to 28.8°C) and east of Andros Island (depth 1464 to 1546 temperature 4.0°C). Rodd and Brönnimann (1957) reported its common occurrence at 4 to 23 m depth from Gulf of Paria as a member of offshore zone, which is characterized by soft gray blue to green mud. T. tricarinata is a cosmopolitan species of Triloculina having sharp triangular outline and has been reported from the west as well as east coast of

India, but is rare in occurrence. Bhatia (1956) reported this species from Juhu, Bhogat and Chowpatty beaches. Antony (1968) described it at 12 to 100 m depth range from Kerala. Seibold (1975) recorded it from coast and lagoon of Cochin. Bhatia and Kumar (1976) obtained T. tricarinata from Anjidiv Island near Karwar at 5 to 13 m depth, 22 to 29.4°C temperature and 33.49 to 34.94 ‰ salinity ranges. Recently, Rao and Rao (1979) found it in nearshore water, off Trivandrum. From the east coast, Bhalla (1968) reported it from the beach sand of Vishakhapatnam. Recently Rao et al. (1979) encountered T. tricarinata from the sediments of shelf off Vishakhapatnam at 20 to 190 m depth range. Haake (1971) studied wall structure of T. tricarinata and found brick structure of wall.

Summary of ecological data: Depth upto 1546 m, temperature 23.0 to 29.4°C, salinity 33.49 to 34.94 ‰.

Repository of type material: AMUGD cat. No. MF 232.

Triloculina trigonula (Lamark)

Plate 3, figure 11.

Miliolites trigonula LAMARK, 1804, p. 351, pl. 17, fig. 4.

Miliolina trigonula WILLIAMSON.- BRADY, 1884, p. 164, pl. 3, figs. 14-16.

Triloculina trigonula (Lamark) D'ORBIGNY, 1826, p. 229, pl. 16, figs. 5-9.- BHATIA and BHALLA, 1964, p. 79, pl. 1, figs. 5a-b.- ROCHA and UBALDO, 1964a, p. 7, pl. 5, figs. 5a-b.- BHALLA, 1968, p. 382, pl. 1, figs. 2a-b; 1970, p. 157, pl. 20. figs. 4a-b.- RAO, 1970a, p. 592. pl. 3, figs. 21a-b.

Dimensions (in mm): Length 0.37 to 0.39 width, 0.32 to 0.34, thickness 0.13.

Remarks: This cosmopolitan species of *Triloculina* was reported by Brady (1884) from Medagascar shore sands and from shallow water of Ceylon. From the Indian waters, *T. trigonula* was reported by Bhatia and Bhalla (1964) from Puri beach sand and Bhalla (1968, 1970) from Vishakhapatnam and Marina beach sands respectively, from the east coast of India, while Rocha and Ubaldo (1964a) recorded it from Diu, Gogola and Simbor beaches and Rao (1970a) from Gulf of Cambay, on the west coast of India. The known geological age of this species from Eocene to Recent.

Repository of type material: AMUGD cat. No. MF 233.

Genus *Miliolinella* Wiesner, 1931

Miliolinella australis (Parr)

Plate 4, figure 1

Quinqueloculina australis PARR, 1932, p. 7.

Miliolinella australis BARKER, 1960, p. 10, pl. 5, figs. 10-11.

Dimensions (in mm): Length 0.32 to 0.34, width 0.24 to 0.26, thickness 0.13 to 0.14.

Remarks: Brady (1884) reported *M. australis* (= *Miliolina subrotunda*) from the Pacific at a depth of 70 to 73 m. Later, Barker (1960) placed it under genus *Miliolinella* with some reservation. Betjeman (1969) recorded *M. australis* from the Western Australian continental shelf as member of outer shelf facies (73 to 219 m).

Depth range: upto 219 m.

Repository of type material: AMUGD cat. No. MF 234.

Miliolinella oblonga (Montagu)

Plate 4, figure 2

Vermiculum oblongum MONTAGU, 1803, p. 522, pl. 14, fig. 9.

Miliolinella oblonga (Montagu) BHATIA, 1955, p. 671, pl. 67, fig. 17.

Dimensions (in mm): Length 0.33 to 0.34, width 0.24 to 0.26, thickness 0.12 to 0.14.

Remarks: Our specimens resemble to figures of M. oblonga given by Kaasschicter (1960, p. 152, pl. 3, figs. 7-8), according to whom "most of the specimens show a quinqueloculina arrangement of the chamber and thus should belong to genus Scutuloris Loeblich and Tappen. However, triloculine specimens were met with as well and some intermediate between both types are present". Bhatia (1955, p. 671) remarked, "there is no fundamental difference between these two types. Consequently, the genus Miliolinella is valid for both and there is some doubt as to the validity of the genus Scutuloris". Haman (1971) recorded M. oblonga from estuarine (salinity 0.5 to 16.5 ‰), shoal (0 to 18 m depth, 16.5 to 33.5 ‰ salinity, strong current action, medium to coarse sand with occasional pebbles and boulders) and shallow (19 m depth, 33.5 to 34.0 ‰ salinity, weaker current, silty mud to very fine sand) environments from Tremadoc Bay, North Wales, U. K.

Summary of ecological data: Depths upto 19 m, salinity 33.5 to 34.0 ‰.

Repository of type material: AMUGD cat. No. MF 235.

Suborder ROTALIINA Delage and Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838.

4.3.6 Family NODOSARIIDAE Ehrenberg, 1838.

Subfamily NODOSARIINAE Ehrenberg, 1838.

Genus NODOSARIA Lamark, 1812.

Nodosaria sp.

Plate 4, figure 14

Dimensions (in mm): Length 0.38, diameter 0.10.

Remarks: A solitary, rather worn, specimen having a smooth, multilocular uniserial test with depressed sutures, perpendicular to the axis of the test, was found which could not be referred to any known species of *Nodosaria*. More well preserved specimens are required before a specific name can be assigned.

Repository of type material: AMUGD cat. No. MF 236.

Genus LAGENA Walker and Jacob, 1798.

Lagena laevis (Montagu)

Plate 4, figure 7.

Vermiculum laevis MONTAGU, 1803, p. 524.

Lagena laevis BRADY, 1884, p. 455, pl. 56, figs. 9, 10.- SETHULEKSHMI AMMA, 1958, p. 55, pl. 2, figs. 84 a-b.- ANTONY, 1968, pp. 56-57, pl. 3, figs. 23 a-b.- RAO, 1971b, p. 158, fig. 22; 1974, fig. 23.- SEIBOLD, 1975, p. 183.- BHATIA and KUMAR, 1976, p. 242, pl. 2, fig. 9.

Dimensions (in mm): Length 0.51, Diameter 0.16.

Remarks: Brady (1884) recorded L. laevis from Falkland Island, South Atlantic (depth 11 m) and Torres strait, Pacific (depth 284 m). Norton (1930) found it's rare occurrence in Younge ocean, about 13 km east of Andros Island at 1464 to 1564 m depth and 4°C temperature. Matoba (1970) encountered this species from outer bay region of Matsuhima bay, North East Japan, at 2.4 to 3.5 m depth. Haman (1971) reported L. laevis from estuarine (salinity 0.5 to 16.5 ‰), shole (0 to 18 m depth, 16.5 to 33.5 ‰ salinity, strong current action, medium to coarse sand with occasional pebbles and boulder) environment from Tremadoc Bay. Seiglie (1975) reported this species from modified marine environment of Guayanilla Bay and Brasier (1975) found only dead specimens of this species from fore-reef (20 to 25 m depth) and bathyal zone, Barbuda.

From the Indian region, L. laevis has been reported by Antony (1968) from Kerala coast at 22 to 183 m depth range; Rao (1971b) from north-eastern part of the Arabian Sea at 16 to 64 m depth and 20 to 24.71°C temperature ranges with muddy (rare occurrence) to sandy (frequent occurrence) substrate; Rao (1974) from the mouth of the Mandovi and Zuari estuaries, Goa, at 4.0 to 7.0 m depth, 27.8 to 28.7°C temperature, 33.91 to 35.15‰ salinity, 0.39 to 0.78 µg/l Phosphate and 1.95 to 10.90 mg/g organic carbon ranges. Bhatia and Kumar (1976) found it from inner-shelf area of Anjidiv Island, near Karwar, at 10.5 to 13 m depth, 29.5°C temperature, 9.5 to 10.5 pH (bottom), 34.39 to 34.56 ‰ salinity, 4.48 to 4.52 ml/l oxygen ranges.

Summary of ecological data: Depth upto 1564 m, temperature 4 to 29.5°C, salinity 0.5 to 35.15 ‰, pH 9.5 to 10.5.

Repository of type material: AMUGD cat. No. MF 237.

Lagena perlucida (Montague)

Plate 4, figure 4

Vermiculum perlucidum Montague, 1803, p. 525, pl. 14, fig. 3.

Lagena perlucida (Montagu) CUSHMAN and McCULLOCH, 1950, p. 342, pl. 46, figs. 19-26.- SETHULEKSHMI AMMA, 1958, p. 55, pl. 2, fig. 83.- GANAPATI and SATYAVATI, 1958, p. 108, pl. 3, fig. 74.- ANTONY, 1968, pp. 55-56, pl. 3, fig. 22.- RAO, 1971b, p. 158, fig. 25.- SEIBOLD, 1975, p. 183, pl. 1, fig. 5.

Dimension (in mm): Length 0.21, diameter 0.13.

Remarks: Todd and Bronnimann (1957) found *L. perlucida* in offshore zone (4 to 23 m) from gulf of Paria. The ecological data of this gulf is as follows: Temperature - 29°C (surface), 27°C (bottom) in dry season and 27 to 28°C (surface), 27°C (bottom) in rainy season; Salinity 35.0 ‰ dry season and 32.5 ‰ in rainy season. Uchio (1962) recorded this species from coast of Wakayama-Ken, Japan, at 7.0 to 8.6 m depth in muddy or sandy substrate. Matoba (1970) reported *L. perlucida* from inner bay region of Matsushima Bay, Japan at 0.9 m depth.

From the Indian region, Ganapati and Satyavati (1958) found rare occurrence of L. perlucida from a station near Godavari delta, Bay of Bengal, at 117 m depth and 17.77°C temperature. Sethulekshmi Amma (1958) recorded it from Kanniyakumari in fine grained sand at 18 to 23 m depth, while Antony (1968) found it at 9 to 183 m depth from Kerala coast. Rao (1971b) observed rare occurrence from North-eastern part of Arabian Sea, off Bombay, at a depth of 64 m in sandy substrate in 23.89 to 24.70°C temperature range. Seibold (1975) encountered very rare occurrence of L. perlucida from lagoon and coast of Cochin, but her illustration does not show striations on the test.

Summary of ecological data: Depth upto 183 m, temperature 23.89 to 27.0°C, salinity 32.5 to 35.0 ‰.

Repository of type material: AMUGD cat. No. MF 238.

<u>Lagena</u> <u>semistriata</u> Willimson

Plate 4, figure 6

<u>Lagena</u> <u>vulgaris</u> var. <u>semistriata</u>, WILLIAMSON, 1948, p. 14, pl. 1, fig. 9-10.

<u>Lagena</u> <u>semistriata</u> WILLIAMSON, BRADY, 1884, pl. 57, figs. 14-18.- RAO, 1971b, p. 158, fig. 27; 1974, pl. 2, fig. 24.

<u>Dimensions (in mm)</u>: Length 0.32, diameter 0.16.

<u>Remarks</u>: <u>L.</u> <u>semistriata</u> is a widely reported species from African coast (Millet, 1901; Herron-Allan and Earland, 1915; Braga, 1960; Albani, 1965). Atkinson (1971) reported it from Cardigan Bay at 26 m depth and Haman (1971) found this species from Tremadoc Bay, in association with <u>L.</u> <u>laevis</u>.

From the west coast of India, Rao (1971b) reported <u>L.</u> <u>semistriata</u> from north-eastern part of the Arabian Sea at 64-77 m depth, and 23.89 to 24.71°C temperature ranges, in sandy to muddy sand substrate; Rao (1974), from mouth of Mandovi and Zuari estuaries, Goa, at 4.0 to 8.5 m depth, 27.8 to 28.7°C temperature, 33.68 ‰ to 35.15 ‰ salinity, 0.58 to 0.78 µg/l Phosphate and 0.69 to 1.95 mg/g organic carbon ranges.

Summary of ecological data: Depth upto 77 m, temperature 23.89 to 28.7°C, salinity 33.68 to 35.15‰.

Repository of type material: AMUGD cat. No. MF 239.

Lagena vulgaris Williamson

Plate 4, figure 5.

Lagena vulgaris WILLIMSON, 1858, p. 3, pl. 1, fig. 5.

Dimension (in mm): Length 0.21, diameter 0.13.

Remarks: Cushman's (1944, p. 21, pl. 3, fig. 7) illustration of *L. vulgaris* resembles well to our specimens. He recorded it's abundance from sand of Bathing Beach and rare occurrence from Vineyard Sound at 11 m and at 24 m depths, off Lambert cove. He also observed that specimens were attached to algae which were washed to shore.

Repository of type material: AMUGD cat. No. MF 240.

4.3.7 Family GLANDULINIDAE Reuss, 1850.

Sub-family OOLININAE Loeblich and Tappan, 1961.

Genus FISSURINA Reuss, 1850.

Fissurina laevigata Reuss

Plate 4, figure 8.

Fissurina laevigata REUSS, 1850, p. 366, pl. 46, fig. 1.- RAO and RAO, 1974, pl. 2, figs. 3a-b.

Lagena laevigata (Reuss).- BRADY, 1884, p. 473, pl. 114, fig. 8a-b.

Dimension (in mm): Length 0.21, diameter 0.15.

Remarks: This cosmopolitan species of *Fissurina* was originally described by Reuss (1850) from the Tertiary marl of Grinzing, near Viena. Uchio (1959) encountered rare specimens of *F. laevigata* from coast of Noboribetsu, Japan, at 56 to 59 m depth in muddy substrate, 12°C temperature, and 25 to 33.8 ‰, salinity ranges. From Indian waters, rare occurrence of this species has been recorded by Rao and Rao (1974) from the Suddagedda estuary, east coast of India.

Repository of type material: AMUGD cat. No. MF 241.

Superfamily BULIMINACEA Jones, 1875.

4.3.8 Family BOLIVINITIDAE Cushman, 1927.

Genus BOLIVINA D'orbigny, 1839.

Bolivina laevigata (Williamson)

Plate 4, figure 13.

Textularia variabilis var. laevigata WILLIAMSON, 1958. p. 77, pl. 6, fig. 168.

Bolivina laevigata (Williamson) Cushman, 1937, p. 159, pl. 16, figs. 1-5.

Dimension (in mm): Length 0.35, diameter 0.10.

Remarks: B. laevigata has been reported from Mer Caltique by Le Calvez (1958b) and from Limski canal, Rovinj, Adria Sea by Danial (1970).

Repository of type material: AMUGD cat. No. MF 242.

Bolivina limbata Brady

Plate 4, figure 10.

Bolivina limbata BRADY, 1881, p. 37; 1884, p. 419, pl. 52, figs. 26-28.- SEIBOLD, 1975, pp. 185-186.

Bolivina limbata (BRADY) var. Costulatumm, CUSHMAN, 1942, p. 35, pl. 10, figs. 2-4.

Bolivina limbata var costulata CUSHMAN, 1922, p. 26, pl. 3, fig. 8.

Loxostomum limbatum (Brady) var. costulatum CUSHMAN, 1942, p. 35, pl. 10, figs. 2-4.- ANTONY, 1968, D, p. 76, pl. 5, fig. 6.

Loxostomum limbatum ROCHA and UBALDO, 1964a, p. 414, pl. 2, fig. 9.

Dimensions (in mm):	(a) Megalospheric -	Length	0.20
		Width	0.10
		Thickness	0.03
	(b) Microspheric -	Length	0.26
		Width	0.10
		Thickness	0.04

Remarks: Microspheric and megalospheric generations of Bolivina limabata are present in the present assemblage.

These specimens resemble well to those illustrated by Brady (1844) from the Pacific (29 to 73 m). Lutze (1974) found *B. limbata* from the Persian Gulf.

From the west coast of India, Seibold (1975) recorded a few specimens of *B. limbata* from Cochin and considered that *L. limbatum* as described by Antony (1968) and Rocha and Ubaldo (1964a) are junior synonyms of *B. limatata*.

Repository of type material: AMUGD cat. No. MF 243.

<u>*Bolivina persiensis*</u> Lutze

Plate 4, figure 9.

<u>*Bolivina persiensis*</u> LUTZE, 1974, pl. 5, figs. 86-89, pl. 6, fig. 98.- SEIBOLD, 1975, p. 186, pl. 1, fig. 16.

<u>Dimensions (in mm)</u>:	(a) Megalospheric -	Length	0.23
		Width	0.13
		Thickness	0.05
	(b) Microspheric -	Length	0.28
		Width	0.15
		Thickness	0.04

<u>Remarks</u>: Lutze (1974) gave a detailed description of <u>*B. persiensis*</u> from samples of Persian Gulf. Recently, Seibold (1975) found dead population of this species from deeper samples of Cochin west coast, India. Both, microspheric and megalospheric generations are present in our material.

<u>Repository of type material</u>: AMUGD cat. No. MF 244.

<u>Bolivina striatula</u> Cushman.

Plate 4, figure 11.

<u>Bolivina striatula</u> CUSHMAN, 1922, p. 27, pl. 3, fig. 10.- BHATIA, 1956, p. 21, pl. 1, fig. 9.- RAO, 1971b, p. 160, fig. 45.-RAO and RAO 1974, pl. 2, fig. 1.-SEIBOLD, 1975, pp. 186-187, pl. 1, fig. 17.

<u>Bolivina nobalis</u> HANTKEN, SETHULEKSHMI AMMA, 1958, p. 45, pl. 2, fig. 68.-ANTONY, 1968, p. 73, pl. 4, fig. 20.-RAO, 1970b, p. 267, pl. 5, fig. 54.-REDDY and RAO, 1980, p. 165, pl. 3, fig. 12.

<u>Brizalina striatula</u> (Cushman) SLITER, 1970, p. 170, pl. 7, figs. 6a-d, pl. 8, fig. 19.

<u>Dimensions (in mm)</u>:	(a) Megalospheric -	Length	0.35 to 0.37
		Width	0.13 to 0.14
		Thickness	0.06 to 0.07
	(b) Microspheric -	Length	0.39 to 0.41
		Width	0.13 to 0.15
		Thickness	0.06 to 0.07

Remarks: This cosmopolitan species of Bolivina has been reported by Norton (1930) from Bird Key Harbour, Florida, at 10 m depth and 22.6 to 24.8°C temperature range and from Tortugas, Florida, at 15 m depth with 22.6 to 24.7°C temperature range; Cushman (1944) from Vineyard Sound, New England Coast, at 11 m depth, off Nonamesset Island, and at 18 m depth, off Mnemsha; Todd and Brönnimann (1957) from Eastern Gulf of Paria at 4 to 33 m depth and temperature range from 27°C (bottom) to 28°C (surface) in rainy season and 27°C (bottom) to 29°C (surface) in dry season, salinity ranges from 32.5 ‰ (bottom) to 32.5 ‰ (surface) in rainy season and 35.0 ‰ in dry season while chlorinity ranges from 18‰ (bottom) to 17 ‰ (surface) in rainy season and 19.4 ‰ in dry season. Lankford (1959, p. 2095) found it from East Mississippi delta margin and observed "Some of the Sound species, such as Ammotium salsum, Bolivina striatula and Elphidum matagordanum, apparently have adopted to the marginal marine conditions and are found only rarely in the normal marine environment". Uchio (1962) recorded this species from Mori harbour, coast of Wakayama-Ken, Japan, at 6.4 to 8.6 m depth, but he did not find any specimen in the nearby beach sediments. Sen Gupta and Schafer (1973) reported B. striatula from Castries Bay at a depth of 4 to 17 m with mean temperature 25.8°C, mean salinity 35.8 ‰, and mean pH 8.2 and from Chock Bay at a depth of 9 to 14 m and 26.4°C mean temperature 34.7 ‰ mean salinity and 7.9 mean pH. Seiglie (1970) described B. striatula (= Brizalina striatula) as a member of fluvial-marine facies in the Yabucoa bay, South-East Puerto Rico, having 34 ‰ to 35 ‰ salinity range. More recently, Golic and Phleger (1977) obtained living specimens (0 to 13%) of this species as a member of outer shelf fauna at a depth of 65 to 200 m, temperature 15 to 19°C, and salinity 34.5 to 35.0 ‰ in the silty mud, muddy sand, and sandy substrate from Gulf of Panama.

From the Indian region, B. striatula is known from east and west coasts. From the east coast, Rao and Rao (1974) obtained it from Suddagedda estuary at 28.35 ‰ salinity, 24°C temperature and 2.45 ml/l dissolved oxygen, and 0.13 to 0.80 % organic matter in sandy substrate while from the west coast, B. striatula was reported by Antony (1968) as frequent species at a depth of 46 to 183 m from Kerala Coast; Rao (1970b) at 27.4 m depth in muddy substrate from Gulf of Cambay, and Rao (1971b) from the north-eastern part of Arabian Sea at 27 to 64 m depth and 21.71 to 24.71°C temperature ranges in muddy to sandy substrate. Seibold (1975) found it as most common living species (20%) in deeper sample (20 m), and also recorded dead specimens in samples from Cochin lagoon. Sliter (1970), during the taxonomic study of inner neritic Bolivinitidae from the Eastern Pacific margin, identified specimens as Brizalina striatula and observed that it is a cosmopolitan species ranging in latitude from at least 50°N to 47°S. However, in later years, Lutze (1974) again changed its taxonomic position and put it in the synonymy of Bolivina striatula.

Summary of ecological data: Depth upto 200 m, temperature 15 to 29°C, salinity 28.35 to 35.0 ‰, pH 7.9 to 8.2.

Repository of type material: AMUGD cat. No. MF 245.

<u>Bolivina</u> cf. <u>variabilis</u> (Williamson)

Plate 4, figure 12.

<u>Textularia</u> <u>variabilis</u> WILLIAMSON, 1858, p. 76, pl. 6, figs. 162-163.

<u>Bolivina</u> <u>variabilis</u> (William), CHASTER, 1890-91 (1892), p. 59 to 69.- BHATIA, 1956, p. 21 pl. 1, fig. 8.

<u>Dimensions (in mm)</u>: (a) Megalospheric - Length 0.28

(a) Megalospheric	-	Length	0.28
		Width	0.15
		Thickness	0.05
(b) Microspheric	-	Length	0.41
		Width	0.13
		Thickness	0.04

<u>Remarks</u>: Todd and Brönnimann (1957) reported <u>B. variabilis</u> from 4 to 33 m depth range from Eastern Gulf of Paria. Sliter (1970, p. 166) described this species from Eastern Pacific margin of Mexico and inferred"....species is cosmopolitan in distribution and ranges at least from the North Sea to the Antarctic Region". From the Indian waters <u>B. variabilis</u> was recorded by Bhatia (1956) from Juhu, Bhogat and Chowpatty beaches, west coast India. The known geological range of this species from Oligocene to Recent.

<u>Depth range</u>: upto 33 m.

<u>Repository of type material</u>: AMUGD cat. No. MF 246.

4.3.9 Family BULIMINIDAE Jones, 1875.

Subfamily BULIMINIAE Jones, 1875.

Genus BULIMINA D'orbigny, 1826.

Bulimina marginata D'orbigny

Plate 4, figure 15.

Bulimina marginata D'ORBIGNY, 1826, p. 269, pl. 12, figs. 10-12.- BHATIA, 1956, p. 20, pl. 1, fig. 4.- SETHULEKSHMI AMMA, 1958, p. 44, pl. 2, figs. 66a-b.- ANTONY, 1968, p. 67, pl. 4, fig. 11.- RAO, 1970b, p. 266, fig. 51; 1971, p. 159.- RAO, VEDANTAM and RAO, 1979, p. 358.

Dimensions (in mm): Length 0.28, width 0.14.

Remarks: B. marginata is a cosmopolitan species and its known geological range is from the Miocene to Recent. It has been recorded by Brady (1884) from 2983 m depth, west of Ireland, while Norton (1930) noted its frequent occurrence from Florida at 109 m depth and 20.6°C temperature. Said (1949) reported abundant specimens of this species from 59 to 64 m depth from Red Sea. Todd and Bronniman (1957) obtained high frequency of B. marginata from 4 to 33 m depth (offshore zone), Eastern Gulf of Paria, which is characterised by soft, grey-blue to green mud in the deeper parts.

Parker (1954) obtained this species upto a depth of 530 m from north-eastern Gulf of Mexico and showed that it does not occur sholar than 75 m except at one station. It was reported from shallow to 2981 m depth in the north Atlantic by her (Parker, 1958). B. marginata has been reported by Lankford (1959) from deltaic margin, sound, and open shelf from east Mississippi delta margin, but it prefers water having 18 to 36 ‰ salinity and 15 to 22°C temperature range; Uchio (1962) from Shiraki beach sand and Mori harbour (6 m depth) along the coast of Wakayama-ken, Japan; Ishiwada (1964) from Honshu at 44 to 1180 m depth and from Tosa Bay at 56 to 680 m depth, off the Pacific coast of Japan; Phleger (1964) from Gulf of California at 73 to 92 m depth zone in living form; Matoba (1970) from mouth of Matsushima Bay, Japan, at 12.5 m depth as a member of outer bay facies; Lankford and Phleger (1973) from nearshore, turbulent zone, 6 to 38 m depth, from western north America; Seiglie (1974) from polluted marine environment of Mayaguez Bay at 7.9 to 8.4 pH, 24.9 to 29.3°C bottom water temperature, 25.1 to 29.6°C surface water temperature and 33.28 to 36.78 ‰ salinity ranges. Sen Gupta and Schafer (1973) encountered B. marginata from Castries Bay at 4 to 12 m depth in muddy to sandy mud substrate with 25.8°C mean temperature, 35.8 ‰ salinity and 8.2 mean pH. Recently, Sen Gupta (1977, p. 80) summarised the distribution of modern benthonic foraminifera on continental shelves of the world oceans and concluded "...and _Bulimina marginata_ D'orbigny, attain their highest abundance in bathyal or abysal water".

From the west coast of India, _B. marinata_ was reported by Bhatia (1956) from Juhu beach sand; Sethulekshmi Amma (1958) from Kanniyakumari at 18 to 22 m depth; Antony (1968) from Kerala coast at 46 to 183 m depth; Rao (1970b) from Gulf of Cambay at 27.4 m depth in muddy substrate and abundant (Rao, 1971a) in north-eastern part of the Arabian Sea at 16 to 64 m depth. Recently, Rao _et al_ (1979) recorded it's continuous distributions at 20 to 90 m depth and erratic distribution in 90 to 190 m depth range from Vishakhapatnam shelf, east coast of India.

Summary of ecological data: Depth upto 2983 m, temperature 15 to 29.5°C, salinity 18 to 36 ‰, pH 7.9 to 8.4.

Repository of type material: AMUGD cat. No. MF 247.

4.3.10 Family UVIGERINIDAE Haeckel, 1894.

Genus UVIGERINA D'orbigny, 1826.

Plate 4, figure 16.

Uvigerina auberiana D'ORBIGNY, 1839, p. 106, pl. 2, figs. 23-24.- ZOBEL, 1973, pl. 1, fig. 64.

Dimensions (in mm): Length 0.26, diameter 0.13.

Remarks: Norton (1930) recorded rare occurrence of *U. auberiana* at 922 to 3724 m depth and 1.83°C to 7.61°C temperature ranges. Parker (1954) reported it from north-east Gulf of Mexico and recorded (Parker, 1958) it at 15 stations from Eastern Mediterranean Sea from 179 to 731 m depth and at 1265 m depth at 4 stations (showing displaced fauna). Uchio (1960) found living specimens of this species at 915 to 1144 m depth and dead specimens at 676 to 1191 m depth ranges. Bandy and Chierichi (1966), on the basis of studies of Parker (1958) and Chierichi *et al.* (1962), suggested a possible bathyal zonation in the Mediterranean Sea based upon upper depth limit of *U. auberiana* occurrence and placed *U. auberiana* D'orbigny in 200 m ± 50 m depth zone. Recently, Golik and Phleger (1977) recorded this species as a member of middle slope fauna from Gulf of Panama at 800 to 1600 m depth, 3 to 8°C temperature, 34.6 ‰ salinity, 0.6 to 2.0 ml/l oxygen ranges in silty mud substrate. Recently, Lohmann (1978) found _U. auberina_ in core top sample at a depth 2272 m and temperature 3.064°C, salinity 34.913 ‰ and oxygen 249 um/kg from western south Atlantic ocean. Uchio (1960, p. 65) observed ", _U. ampullacea_ is within the range of variation of _U. auberiana_. _U. proboscidea_ var. _vadescens_, although it was described from shallow water (21 fathoms), Guam Ahchorage, Ladrone Island, is also within the range of variation _U. auberiana bella_ Dandy (a new name for _U. auberiana laevis_ Goes, not Ehrenberg)(1956, p. 199, vol. 31, fig. 13) is probably a synonym of _U. auberiana_".

Zobel (1973) recorded _U. auberiana_ from the west coast of India.

Summary of ecological data: Depth upto 3724 m, temperature 1.83 to 3°C, salinity 34.6 to 34.9 ‰.

Repository of type material: AMUGD cat. No. MF 248

Genus HOPKINSINA Howe and Wallace, 1932.

Hopkinsina glabra (Millet)

Plate 4, figure 17.

Uvigerina auberiana Orbigny var. glabra MILLET, 1903, p. 268, pl. 5, figs. 8-9.

Uvigerina glabra (Millet) MATOBA, 1970, p. 63, pl. 3, figs. 35 a-b.

Hopkinsina glabra (Millet) LUTZE, 1974, pl. 6, fig. 107.- SEIBOLD, 1975, p. 188, pl. 3, fig. 1.

Dimensions (in mm): Length 0.27, diameter 0.16.

Remarks: Originally, H. glabra was described by Millet (1903) from Malay Archipelago. Matoba (1970) recorded rare specimens of this species from Matsushima bay except for the inner-most parts and its highest occurrence is in the middle part of the bay. Seiglie (1974) obtained living as well as dead specimen of Hopkinsina glabra from the modified environment of Mayaguez bay, off the Central Western Coast of Puerto Rico. In this area, he observed variation in temperature from 24°C to 29°C and salinity 33.3 to 36.8 ‰. Recently, Seibold (1975, p. 188) found common occurrence of H. glabra from offshore and rare occurrence from the lagoon of Cochin and concluded, "The test is covered by tiny tubercles which are sometimes irregularly distributed, but often arranged in a fine striation which cannot be seen with smaller magnifications. It may be that this form is really a cosmopolitan one and cannot be separated from H. pacifica Cushman, 1933 (or H. pacifica var. atlantica Cushman 1944) (see Lutze, 1974)".

Repository of type material: AMUGD cat. No. MF 249.

Genus SIPHOGENERINA Schlumberger, 1882.

Siphogenerina raphanus (Parker and Jones).

Plate 4, figure 3.

Uvigerina (sagrina) rephanus, PARKER and JONES 1865, p. 364, pl. 18, figs. 16-17.

Siphogenerina rephanus (Parker and Jones) CUSHMAN, 1942, p. 55, pl. 15, figs. 6-9.- BHATIA, 1956, p. 21, pl. 1, fig. 6.- BARKER 1960, p. 156, pl. 75, figs. 21-24.- ROCHA and UBALDO, 1964a, p. 7, pl. 5, fig. 3.- REDDY and RAO, 1980, p. 168, pl. 2, fig. 16.

Dimensions (in mm): Length 0.52 to 0.61, width 0.13 to 0.14.

Remarks: S. rephances is a widely distributed species. Ishiwada (1964, pl. 5, fig. 81) encountered it from the Pacific coast of Japan at 64 to 1111 m depth. Bhatia (1956) recorded its abundance in Juhu sands while rare at Chowpatty beach. Rocha and Ubaldo (1964a) observed its rare occurrence in Diu beach sand. Recently, Reddy and Rao (1980) recorded it from Pennar estuary, Andhra Pradesh, east coast of India.

Repository of type material: AMUGD cat. No. MF 250.

Superfamily DISCORBACEA Ehrenberg, 1838.

4.3.11 Family DISCORBIDAE Ehrenberg, 1838.

Subfamily BAGGININAE Cushman, 1927.

Genus CANCRIS De Montfort, 1808.

Cancris auricula (Fichtel and Moll)

Plate 4, figure 18.

Nautilus auriculus FICHTEL and MOLL, 1798 (1803). var. , p. 108, pl. 20, figs. 1-c, var. β , p. 110, pl. 20, figs. d-f.

Cancris auriculus (Fichtel and Moll).-LeROY, 1941. p. 117, pl. 3, figs. 7-9, 16-18.-ANTONY, 1968, pp. 97-98, pl. 7, figs. 5a-b.-ZOBEL, 1973, pl. 1, figs. 18-20.

Cancris auricula (Fichtel and Moll).- CUSHMAN, 1927, p. 164, pl. 5, fig. 10.- BHATIA, 1956, p. 23, pl. 5, figs. 5a-b.-RAO, 1971b, p. 161, fig. 52.- SEIBOLD, 1975, p. 190, pl. 4, figs. 1a-b.

Dimensions (in mm): Length 0.28 to 0.37, width 0.20 to 0.30, thickness 0.10 to 0.14.

Remarks: C. auricula is a well-known, cosmopolitan, species, commonly occurring in offshore rather deep water (92 to 366 m) zone and is rare in shallow waters. Walton (1955) recorded this species from Todes Santos Bay, Baja California at 55 to 550 m depth range. Phleger (1964) found living specimens of C. auricula at 13 to 174m depth range from Gulf of California where temperature range from 15.0 to 30.0°C (North Gulf) and 21 to 30°C (South Gulf). Lankford and Phleger (1973) observed living specimens of this species at 6 to 30 m depth range from west north America. Lutze (1974) recorded its abundant occurrence in coarser sedimentary substrate. Adegoke et al. (fide Sen Gupta, 1977) recorded"... not abundant occurrence in depth zone 0 to 10 m. However, it is frequent at 10 to 40 m depth and rare at 40 to 120 m depth". Recently, Murray (1979) recorded more than 10% of living forms of C. auricula from Celtic sea at depths less than 110 m in muddy substrate. In India, C. auricula is known only from the west coast. It has been reported by Bhatia (1956) from Juho beach sands Bombay; Rao (1971b) from north-eastern part of the Arabian Sea, Antony (1968) from Cochin at 35 m depth; and Seibold (1975) from lagoon and coast of Cochin.

Summary of ecological data: Depth upto 550 m, temperature 15.30°C.

Repository of type material: AMUGD cat. No. MF 251.

Superfamily DISCORBACEA Ehrenberg, 1838.

4.3.12 Family GLABRATELLIDAE Loeblich and Tappan, 1964.

Genus GLABRATELLA Dorreen, 1948.

Glabratella patelliformis (Brady).

Plate 4, figure 20.

Discorbina patelliformis BRADY, 1884, p. 647, pl. 88, figs. 3a-c, pl. 89, figs. 1a-c.

Discorbis patelliformis (Brady) CUSHMAN, TODD and POST, 1954, p. 359, pl. 89, fig. 7.- SETHULEKSHMI AMMA, 1958, p. 65, pl. 3, figs. 99a-b.

Neoconorbina patelliformis (Brady) TODD, 1965, p. 15, pl. 1, fig. 7.

Glabratella cf. patelliformis (Brady) MATOBA, 1970, p. 54, pl. 5, figs. 3a-c.

Dimensions (in mm): Length 0.35, width 0.32, thickness 0.25.

Remarks: Brady recorded G. patelliformis from the Pacific at 11 to 31 m depth. Sethulekshmi Amma (1958) found it from Alleppey in clay substrate. Recently, Matoba (1970) reported G. pettelliformis from Matsushima Bay, north-east Japan at 1.2 to 12.5 m depth. This species is also known from north Pacific, Ceylon, Madagaskar, Mauritius and Malta.

Repository of type material: AMUGD cat. No. MF 252.

Glabratella sp.

Plate 4, figure 19.

Dimensions (in mm): Length 0.22, width 0.18, thickness 0.10.

Remarks: Only two, small, probably juvianile specimens of Glabratella were found in our material which could not be assigned to any known species of this genus. However, some more specimens are needed for specific identification.

Repository of type material: AMUGD cat. No. MF 253.

4.3.13 Family EPISTOMARIIDAE Hokter, 1954.

Genus PSEUDOEPONDIDES Uchio, 1950.

Pseudoeponides nakazotoensis (Kuwano)

Plate 4, figure 21.

Epistomaria (Epistomariella) nakazotoensis KUWANO, 1950, p. 316, figs. 4a-c, 11.

Pseudoeponides paucilоculata (Phleger and Parker), SEIBOLD, 1971, p. 47, text, fig. 3, pl. 7, figs. 3-6.- ZOBEL, 1993, pl. 1, figs. 1-3.

Pseudoeponides nakazotoensis (Kuwano) UCHIO, 1953, p. 157, pl. 14, figs. 6a-c.- SEIBOLD, 1975, pp. 190-191.

Dimensions (in mm): Length 0.29 to 0.31, width 0.26 to 0.27, thickness 0.14 to 0.16.

Remarks: Recently, Seibold (1975) found only rare, dead, specimens of P. nakazotoensis in samples from offshore shallow water, few living ones at two deeper stations and some scattered empty tests from lagoon of Cochin, east coast of India and observed (Seibold, 1975, p. 191), "It is of interest that Rotalia pauciloculata from the Gulf of Mexico has the same marked distribution with depth as the Indian Pseudoeponides and has the same association with Rolshausenia rolshauseni, Cushman and Bermudez which is nearly identical with Asterorotalia inflata (Millet)". Bhatia and Kumar (1976, p. 243) recorded similar species---"Pseudoeponides" equatorina (Le Roy)- and noted, "The species is undoubtedly close to Pseudoeponides nakazotoensis (Kuwano) from Plio-Pleistocene of Japan, which has been recently transferred to the new genus Taxyella by Anglada and Magne (1969, p. 370). Since the exact taxonomic position of genus Taxyella vis-a-vis Pseudoeponides (and Helenina) is still uncertain, the present species is assigned to "Pseudoeponides" with some reservations". However, Seibold's (1975) identification has been followed here because of it's close resemblence to our specimens.

Repository of type material: AMUGD cat. No. MF 254.

Superfamily ROTALIACEA Ehrenberg, 1839.

4.3.14 Family ROTALIIDAE Ehrenberg, 1839

Subfamily ROTALIINAE Ehrenberg, 1839.

Genus AMMONIA Brunich, 1772.

Ammonia annectens (Parker and Jones)

Plate 4, figures 24, and 25.

Rotalia beccarii (Linnaeus) var. annectens.- PARKER and JONES, 1865, p. 387, 422, pl. 19, figs. 11a-c.

Streblus annectens (Parker and Jones).- ISHIZAKI, 1940, p. 58, pl. 3, figs. 12-13.- BHATIA, 1956, p. 22, pl. 3, figs. 1-2.- BHATIA AND BHALLA, 1964, p. 79, pl. 2, figs. 1a-c.- ROCHA and UBALDO, 1964a, p. 417, pl. 4, figs. 3a-c, 1964b, p. 647, pl. 2, figs. 13-14.

Ammonia annectens (Parker and Jones).- HUANG, 1964, pp. 50-52, pl. 2, fig. 3; pl. 3, figs. 1-2, text fig. 3.- BHALLA, 1970, p. 158, pl. 20, figs. 8a-c.- BHATIA and KUMAR, 1976, p. 247 (Table).- RAO, VEDANTAM and RAO, 1979, p. 360.

Dimensions (in mm): (a) Megalospheric - Length 0.43 to 0.62

Width 0.4 to 0.5

	Thickness	0.36 to 0.38
	Proloculus	48 to 52 μ
(b) Microspheric -	Length	0.500 to 0.72
	Width	0.55 to 0.63
	Thickness	0.26 to 0.32
	Proloculus	9 to 11 μ

<u>Dimorphism and variation</u>: <u>A.</u> <u>annectens</u> shows a wide range of variation in shape and size of the test and also in the number of chambers. Dimorphic generations can be distinguished in the present material of <u>A.</u> <u>annectens</u> (pl. 4, figures 24a-c, 25a-c). The microspheric individuals have a proloculus diameter of 11 μ (pl. 4 figure 25b) while the diameter of megalospheric proluculus is about 50 μ (pl. 4, figure 24b). Sinistral as well as dextral forms are found in the present material but no correlation with dimorphic generations could be made. The total number of chambers varies

from 20 to 30 in microspheric and 18 to 22 in megalospheric forms. The periphery shows a little variation in the lobulation as well as in the presence of marginal keel which is reflected only in the smaller specimens. Some specimens show comparatively more raised umblical region than the others.

Remarks: *Ammonia annectens* is a well-known Indo-Pacific species and occurs abundantly in our material. From the east coast of India, Bhatia and Bhalla (1964) described this species from Puri beach sands and Bhalla (1970) from Marina beach sands, Madras. Recently, Rao *et al.* (1979) recorded *A. annectens* from shelf region off Vishakhapatnam at 20 to 90 m depth zone. From the west coast, Bhatia (1956) reported it from Juhu, Chowpatty and Bhogat beaches and Rocha and Ubaldo (1964a, b) from Diu, Gogola, Simbor, Jampore and Baga beaches. Bhatia and Kumar (1976) obtained it from Anjidiv Island near Karwar at 5 to 14.5 m depth, 28.5 to 30.1°C temperature, and 33.49 to 35.01 ‰ salinity range. The known geological range of this species is from Miocene to Recent.

Summary of ecological data: Depth upto 80 m, temperature 28.5 to 30.1°C, salinity 33.49 to 35.01 ‰.

Repository of type material: AMUGD cat. No. MF 255.

Ammonia indica (Le Roy)

Plate 5, figure 3.

Rotalia indica Le ROY, 1939, p. 257, pl. 2, figs. 17-19.

Streblus indicus (Le Roy)- CHANG, 1960, pl. 14, figs. 7a-c, pl. 15, figs. 2a-b.

Ammonia indica (Le Roy)- HUANG, 1964, p. 53, pl. 2, fig. 7.

Dimensions (in mm): Length 0.61 to 0.62 width 0.50 to 0.51, thickness 0.37 to 0.38.

Remarks: Only a few slightly broken, specimens of A. indica were found in our material which show resemblance to those figures by Huang (1964). Ammonia indica was originally described as Rotalia indica by Le Roy from the Miocene of Sumatra. It is an Indo-Pacific species and this is first report of A. indica from Indian waters.

Repository of type material: AMUGD cat. No. MF 256.

<u>Ammonia papillosus</u> (Brady)

Plate 5, figures 1 and 2

<u>Rotalia papillosa</u> BRADY, 1884, p. 708, pl. 106, fig. 9.- GANAPATI and SATYAVATI, 1958, p. 116, pl. 5, figs. 124-125.- ANTONY, 1968, pp. 93-94, pl. 6, figs. 9a-b.

<u>Streblus papillosus</u> (Brady).- BHATIA, 1956, p. 23, pl. 4, figs. 1-2.- ROCHA and UBALDO, 1964a, p. 12, pl. 4, figs. 7a-c; 1964b, pl. 2, figs. 21-23.

<u>Ammonia papillosus</u> (Brady).- RAO, VEDANTAM and RAO, 1979, p. 357.

<u>Ammonia papillosus</u> (Brady).- NIGAM, SETTY and AMBRE, 1979, p. 245.

<u>Dimensions (in mm)</u>: (a) Megalospheric . Length -0.76 to 0.78

Width	0.66 to 0.67
Thickness	0.42 to 0.43
Proloculus	79 to 84 μ

(b) Microspheric	- Length	0.85 to 0.90
	Width	0.75 to 0.82
	Thickness	0.44 to 0.45
	Proloculus	24 to 28 μ.

Dimorphism and variation: The phenomenon of dimorphism was observed in *A. papillosus* found in the present material (pl. 5, figures 1, 2). The microspheric individuals have a proluculus diameter 26 μ (pl. 5, figures 1 b) and 39 to 43 chambers whereas megalospheric generations have proluculus diameter 81 μ (pl. 5, figure 2b) and 19 to 22 chamber in the last whorl. The size of test varies from 0.76 to 0.78 mm in megalospheric generation and 0.85 to 0.90 mm in microspheric generation.

Remarks: *Ammonia papillosus* is an Indo-Pacific species and is characterised by strongly biconvex test and beaded nature of sutures. From the East Coast of India, it has been reported by Ganapati and Satyavati (1958) at 18.5 to 154 m depth and 17.8 to 28.3°C temperature range. Rao *et al.* found it from shelf region off

Vishakhapatnam at 20 to 190 m depth. From the west coast, Bhatia (1956) recorded it from Juhu beach, Bombay; Rocha and Ubaldo (1964a,b) from Diu, Gogola, Simbor, Jampore and Baga beaches; Antony (1968) from Kerala coast at 12 to 50 m depth; and Nigam *et al.* from shelf off Ratnagiri in 15 to 50 m depth range.

Summary of ecological data: Depth upto 154 m, temperature 17.8 to 28.3°C.

Repository of type material: AMUGD cat. No. MF 257.

Ammonia sobrina (Shupack)

Plate 4, figure 22

Rotalia beccarii var. *sobrina*, SHUPACK 1934, p. 6, pl. 6, figs. a-c.

Ammonia beccarii.- ROCHA and UBALDO, 1964b, p. 647, pl. 2, figs. 17-18.

Ammonia sobrina (Shupack).- SEIBOLD, 1971, p. 46, pl. 6, figs. 4-6, pl. 7, figs. 1-2, text fig. 2; 1975, p. 191.

Dimensions (in mm): Length 0.30 to 0.32, width 0.29 to 0.32, thickness 0.16 to 0.17.

Remarks: Todd and Brönnimann (1957) recorded *A. sobrina* as *Streblus beccarii* (Linnie) var. *Sobrina* (Shupack) from the Eastern Gulf of Paria in tidal and nearshore zone (0 to 4 m depth). Recently, Seibold (1975) identified that living specimens of *A. sobrina* were restricted to the lagoon samples (up to 58%) from Cochin.

Repository of type material: AMUGD cat. No. MF 258.

Ammonia tepida (Cushman)

Plate 4, figure 23.

Rotalia beccarii var. *tepida* CUSHMAN, 1926, p. 79, pl. 1.- RAO, 1974, pl. 2, figs. 33a-b.

Discorbis rosacea (D'orbigny).- ANTONY, 1968, p. 91, pl. 5, figs. 23a-b.

Discorbis tepida (Cushman).- SEIBOLD, 1971, p. 44, text fig. 1, pl. 5, figs. 4-6, pl. 6, figs. 1-3.

Ammonia tepida (Cushman).- RAO and RAO, 1974, pl. 2, figs. 10a-b.- SEIBOLD, 1975, pp. 191-192, BHATIA and KUMAR, 1976, p. 249.- SETTY, 1976, p. 229.- RAO, VEDANTAM and RAO, 1979, p. 360.

Dimensions (in mm): Length 0.28 to 0.30, width 0.24 to 0.26, thickness 0.14 to 0.15.

Remarks: *Ammonia tepida* is a widely recorded species of *Ammonia*. Todd and Brönnimann (1957) reported its abundant occurrence from tidal (including sandy and silty littoral areas with mangrove swamps, mudflats, and estuaries), nearshore, zone (0 to 4 m, sandy and silty sublittoral, and shallow deltaic areas), and offshore zone (4 to 34 m, soft, gray-blue to green mud in the deeper parts) of Eastern Gulf of Paria, Trinidad.

Sen Gupta and Schafer (1973) noted that A. tepida constitutes 10 to 30% of total assemblage in Castries Bay while in Chock Bay, it constitutes less than 5% (Except at st. no. 25); living specimens were more common at stations where water depth was less than 10 m. Mean salinity in Castries Bay was 34.7 ‰ while in Chock Bay 35.8 ‰., temperature was 25.8°C in Choc Bay and 26.4°C in Castries Bay. Seiglie (1970) reported occurrence of this species as an essential member of fluvial marine and bay facies from Yabucoa Bay. He also found (Seiglie, 1974) numerous specimens of A. tepida in polluted marine environment of Mayagüez Bay (24 to 29°C temperature and 33.3 to 36.8 ‰ salinity ranges) as a member of Fursenkonia-Ammonia facies (based on living assemblage) and the sediments associated with this species contain a large amount of vegetable matter. Lefurgey and Jean (1976, p. 289) studied foraminifera in brakish-water, ponds designed for waste control and aquaculture studies in California and concluded, "Ammonia tepida Cushman, occurred in smaller number in the effluent than in the control ponds, indicating that individuals derived in nature at critical oxygen levels between 0.1 and 0.8 mg/l".

From the Indian waters, Rao and Rao (1974, p. 441) recorded this species from Suddagedda estuary, east coast and noted, ".....it abounds in December under favourable conditions of salinity (24.0 to 26 ‰) and temperature (23.5 to 24.0°C) and is apparently dormant in the estuary in other seasons". Recently, Bhatia and Kumar (1976) reported it from Binge Bay near Karwar, west coast at 5 to 14.5 m depth, 9.3 to 10.8 pH (bottom), 3.85 to 4.92 ml/l dissolved oxygen and 33.49 to 34.0 ‰ salinity ranges. Setty, (1976) found large-sized specimens of A. tepida at the proximal zone of the outfall point, in Cola Bay, Goa.

Summary of ecological data: Depths upto 34 m, temperature 23.5 to 29.0°C, salinity 24.0 to 36.8 ‰.

Repository of type material: AMUGAD cat. No. MF 259.

Genus ASTERORОTALIA Hofker, 1950.

Asterorotalia dentata (Parker and Jones).

Plate 5, figure 4.

Rotalia beccarii (Linne') var. dentata, PARKER and JONES, 1865, pp. 387-388, 422, pl. 19, figs. 18a-c.

Streblus dentata (Parker and Jones).- BHATIA, 1956, p. 22, pl. 4, figs, 3a-c.- BHATIA and BHALLA, 1964, p. 80, pl. 2, figs. 2a-c.- ROCHA and UBALDO, 1964c, pp. 416, pl. 4, figs. 6a-b; 1964b, pl. 2, figs. 19-20.

Rotalia calcar HOFKER-GANAPATI and SATYAVATI, 1958, p. 110, pl. 5, figs. 118-119.

Rotalia beccarii (Linne').- SETHULEKSHMI AMMA, 1958, p. 73, pl. 3, figs. 112a_1-a_2, b_1-b_2.

Rotalia calcar D'orbigny-ANTONY, 1968, p. 94, pl. 7, Figs. 11a-b.

Ammonia dentata (Parker and Jones).-BHALLA, 1968, p. 382, pl. 1, figs. 8a-b.- BHATIA and KUMAR, 1976, p. 242 (table).

Ammonia dentatus.- RAO and RAO, 1974, pl. 2, fig. 9.

Asterorotalia dentata (Parker and Jones).- LUTZE, 1974, pl. 7, figs. 117-118.- SEIBOLD, 1975, pp. 192-193, figs. 6a-c, pl. 6, fig. 2.

Dimensions (in mm): (a) Megalospheric - Length 0.40 to 0.43

(a) Megalospheric	Length	0.40 to 0.43
	Width	0.31 to 0.34
	Thickness	0.18 to 0.19
	Proloculus	95 to 100 µ
(b) Microspheric	Length	0.52 to 0.55
	Width	0.42 to 0.45
	Thickness	0.18 to 0.19
	Proloculus	10 to 12 µ

Dimorphism and variation: Both microspheric and megalospheric generations are present in our assemblage of Asterorotalia dentata. The microspheric individuals have 19 to 23 chambers in last whorl with proloculus diameter 11 μ while megalospheric individuals have 10 to 15 chambers and proloculus diameter is 100 μ (pl. 5, fig. 4a-). The size varies from 0.40 to 0.43 mm in megalospheric and 0.52 to 0.55 mm in microspheric generations.

Remarks: A. dentata is a variable species. It has recently been described and discussed in detail by Hofker (1971) from Indonesian shelf, Lutze (1974) from Persian Gulf, and Seibold (1975) from Cochin coast. According to Seibold (1975, pp. 192-193), "contrary to other descriptions of Asterorotalia, here a secondary areal aperture occur together with a normal interio-marginal aperture. The latter ends with a distinct curvature of the apertural face in the middle. This aperture extends to the umblicus, where it is widely open. The areal aperture which is similar to the aperture of Asterorotalia pulchella D'orbigny (see Figure 36 of Hofker, 1971) is triangular with rounded angle and has a thin rim, which is covered and surrounded by fine tubercles. The septal apertures are elongate interiomarginal holes. This means that the two apertures or part of them are fused into a single one".

A. dentata is an Indo-Pacific species. It has been described from the east as well as west coast of India. From the east coast, Bhatia and Bhalla (1964) reported it from Puri beach sands; Ganapati and Satyavati (1958) from near Vishakhapatnam, facing the Bay of Bengal at 40 to 98 m depth range and 17.8 to 31.7°C temperature range; Bhalla (1968) from Vishakhapatnam beach and also (Bhalla, 1970) from Marina beach sand, Madras. Recently, Rao and Rao (1974) recorded it from Suddagedda estuary, Bay of Bengal, at 28.86 to 35.84 ‰ salinity, 24 to 33°C temperature, 2.26 to 3.12 ml/l dissolved oxygen and 0.40 to 1.07 % organic matter ranges. From the west coast, it has been recorded by Bhatia (1956) from Juhu and Bhogat beaches; Sethulekshmi Amma (1958) from Travancore coast; Rocha and Ubaldo (1964a,b) from Diu, Gogola, Simbor, Jampor and Baga beaches; Antony (1968) from Kerala coast at 10 to 100 m depth range; Seibold (1975) from coast and lagoon of Cochin and Bhatia and Kumar (1976) encountered it from Anjidiv Island near Karwar, at 5 to 14.5 m depth, 28.5 to 30.1°C temperature, and 33.49 to 35.01 ‰ salinity ranges.

Summary of ecological data: Depth upto 90 m, temperature 24 to 31°C, salinity 28.3 to 35.8 ‰.

Repository of type material: AMUGD cat. No. MF 260.

Asterorotalia inflata (Millet)

Plate 5, figure 5

Rotalia schroeteriana Parker and Jones var. inflata MILLET, 1904, p. 504, pl. 10, figs. 5a-c.

Asterorotalia inflata (Millet).- SEIBOLD, 1975, pp. 193-194, pl. 3, figs. 7a-b.- VENKATACHALAPATHY and SHAREEF, 1976, pp. 873-875, pl. 1, figs. 3a-c.

Dimensions (in mm): Length 0.31 to 0.35, width 0.23 to 0.25, thickness 0.21 to 0.23.

Remarks: Seibold (1975) made a detailed study of this species from coast and lagoon of Cochin. She found living specimens of A. inflata occurring only below 25 m depth. Lutze (1974) indicate 25 to 40 m depth range for A. dentata from Persian Gulf. Venkatachalapathy and Shareef (1976) recorded this species from Mangalore area, west coast and studied the morphology and microstructure of the test. They showed that sutural canal and dorsal growth are the most important generic characters.

Repository of type material: AMUGD cat. No. MF 261.

Genus PARAROTALIA Le Calvez

Pararotalia calcar (D'orbigny)

Plate 5, figure 10

Calcarina calcar D'ORBIGNY, 1926, p. 276, model no. 34.- BARKER, 1960, p. 222, pl. 108, figs. 3a-c, SETTY, 1976, p. 229.- RAO, 1971b, p. 161.

Rotalia calcar (D'ORBIGNY) SETHULEKSHMI AMMA, 1958, pp. 73-74, pl. 3, figs. 113a-b, GANAPATI AND SATYAVATI, 1958, p. 110, pl. 5, figs. 118-119, ANTONY, 1968, pp. 94-95, pl. 6, figs. 11a-b.- RAO, 1970b, p. 273, fig. 68,

Pararotalia calcar (D'orbigny) CHASENS, 1981, p. 201, pl. 2, figs. 7-9.

Dimensions (in mm): Length 0.63 to 0.67, width 0.47 to 0.49, thickness 0.36 to 0.37.

Remarks: Pararotalia calcar was originally described by D'orbigny (1926) as Calcarina calcar but our specimens show real Pararotalia-type aperture and hence they have been transferred to genus Pararotalia. The identification has been confirmed by Ilse Seibold of Keil University. Similar types of specimens were encountered by Chasens (1981) from Kenya coastline as lagoonal fauna. From the Indian region, P. calcar was described either as Calcarina calar or Rotalia calcar. It was described from the west coast by Sethulekshmi Amma (1958) from Travancore coast; Antony (1968) from Kerala coast; Rao (1970b) from the Gulf of Cambay; (1971b) from north-eastern part of the Arabian sea. However, from the east coast of India Ganapati and Satyavati (1958) recorded it in 40 to 97 m depth and 18° to 26.5°C temperature ranges.

Repository of type material: AMUGD cat. No. MF 262.

Pararotalia minuta (Takayanagi)

Plate 5, figure 11.

Rotalia?minuta TAKAYANAGI, 1955, p. 52, text figs. 29a-c.

Pararotalia minuta (Takayanagi) MATOBA, 1967, p. 256, pl. 27, figs. 5a-b; 1970, p. 58, p. 6, figs. 5-7.

Dimensions (in mm): Length 0.19 to 0.21, width 0.15 to 0.17, thickness 0.11 to 0.12.

Remarks: Pararotalia minuta was reported by Matoba (1970) from the Matsushima Bay, Miyagi prefecture, North-East Japan, as a characteristic species of the outer bay facies. However, it was common in middle bay facies and almost absent in inner bay facies. This is the first report of this P. minuta from Indian waters.

Repository of the type material: AMUGD cat. No. MF 263.

Pararotalia nipponica (Asano)

Plate 5, figure 12.

Rotalia nipponica ASANO, 1936, p. 614, pl. 3, figs. 21-c.

Streblus taiwanica (Nakamura) ROCHA and UBALDO, 1964a, p. 413, pl. 4, figs. 5a-b; 1964b, pl. 2, figs. 15-16.

Pararotalia taiwanica (Nakamura) HUANG, 1964, pp. 55-58, pl. 2, figs. 2a-c.

Pararotalia ozawai (Asano) HUANG, 1964, p. 56, pl. 1, figs. 14a-c.- VENKATACHALAPATHY and SHAREEF, 1976, pp. 371-373, pl. 1, figs. 2a-b.- CHASENS, 1981, p. 196, pl. 2, figs. 13-14.

Pararotalia nipponica (Asano) UJLIE, 1966, pp. 191-200, pls. 24-25.- BHALLA, 1970, p. 158, pl. 20, figs. 6a-c.- BHATIA and KUMAR, 1976, p. 242 (table).- VENKATACHALAPATHY and SHAREEF, 1976, pp. 369-371, pl. 1, figs. 1a-b, NIGAM, SETTY and AMBRE, 1979, p. 249.

Dimensions (in mm): (a) Microspheric .- Length 0.41 to 0.42

Width 0.34 to 0.35

Thickness 0.24 to 0.26

		Proloculus	9 to 11 μ
(b)	Megalospheric	Length	0.36 to 0.37
		Width	0.32 to 0.34
		Thickness	0.24 to 0.25
		Proloculus	25 to 30 μ

Remarks: *Pararotalia nipponic* has been widely recorded from the Indo-Pacific region. As discussed by Bhalla (1972), the other species of *Pararotalia* which either occur along with *P. nipponica* or could be mistaken for it are *Pararotalia taiwanica* (Nakamura) with lobulate periphery and less number of chambers, and *Pararotalia ozawai* (Asano) with smaller size and peripheral spines. Both these species have also been reported from the Indo-Pacific region.

Pararotalia nipponica

Development of labulation on periphery and reduction in the number of chamber

Increase in the size of the test and loss of peripheral spine

Pararotalia taiwanica — Addition of peripheral spines → *Pararolia ozawai*

(After Bhalla, 1972)

Several authors (Haung, 1964; Todd 1965; Ujiie, 1966; Bhalla 1972; Venkatachalapathy and Shareef, 1976) have studied the above mentioned three species of Pararotalia from different points of view, viz., morphological character, diamorphism, microstructure, latitudinal variation, etc. In the present work, views of Bhalla (1972, p. 117) have been followed". In all probability, it seems likely that only P. nipponica is valid whereas P. taiwanica and P. ozawai are its junior synonyms".

Matoba (1970) reported it as common member of outer bay facies and rare in middle bay facies from Matsushima bay, north east Japan. He (Matoba, 1970, p. 57) also observed "The specimens of this species from Matsushima Bay also shows the co-existence of the non-spinate nipponica type and spinate ozawai type, and are always ~~are~~ of larger size in the former and smaller in the latter. Besides in some well preserved large specimens of the nipponica type an earlier stage of the ozawai type with peripheral spines have a few peripheral spines only in the earlier part of the last whorl (pl. 31, figs. 3a-b)."

From Indian waters, Bhalla (1970) recorded this species from Marina beach sands on the east coast. From the west coast, *P. nipponica* was reported by Bhatia and Kumar (1976) at 5 to 13 m depth from Anjidiv Island near Karwar, in 28.5 to 30.1°C temperature and 33.49 to 35.01 ‰ salinity range. Venkatachalapathy and Shareef (1976) recorded it from shelf area, near Mangalore and Nigam *et al.* (1979) from shelf area off Ratnagiri at 15 to 50 m depth range.

Repository of type material: AMUGD cat. No. MF 264.

4.3.15 Family ELPHIDIIDAE Galloway, 1933.

Subfamily ELPHIDIIDAE Galloway, 1933.

Genus ELPHIDIUM DeMontfort, 1808.

Elphidium advenum (Cushman)

Plate 6, figures 1, 4.

Polystomella advena.- CUSHMAN, 1922, p. 56, pl. 9, figs. 11-12.

Elphidium advena (CUSHMAN).- BHATIA, 1956, p. 20, pl. 5, figs. 9a-b.- RAO, 1971b, p. 159, fig. 35.- RAO and RAO, 1974, pl. 3, fig. 2.

Elphidium advenum (CUSHMAN).- CUSHMAN, 1930, p. 25, pl. 10, figs. 1-2.- SETHULEKSHMI AMMA, 1958, p. 22, pl. 1, fig. 34.- BHATIA and BHALLA, 1964, p. 79, pl. 1, figs. 9a-b.- ROCHA and UBALDO, 1964a, pl. 10, pl. 3, fig. 5; 1964b, p. 647, pl. 1, fig. 4.- BHALLA, 1968, pp. 384-385, pl. 2, figs. 5a-b.- ANTONY, 1968, p. 61, pl. 4, fig. 4.- SEIBOLD, 1975, p. 195, pl. 2, fig. 4.- REDDY and RAO, 1980, p. 169, pl. 4, figs. 13-14.

Dimensions (in mm): Major diameter 0.44 to 0.48, minor diameter 0.39 to 0.42, thickness 0.19 to 0.21.

Remarks: This cosmopolitan species of Elphidium occurs in warm and shallow water of tropical regions. Ujiie (1956) made a detailed study of the internal structures of a few species of Ephidium, including E. advenum and E. crispum and observed that E. advenum has only well developed canal system while E. crispum has well-developed canal system and septa spirothecal stolons and this was considered by him as one of the basis for distinguishing these two species.

Norton (1930) recorded E. advenum in depth down to 29 m from Floridian and West Indies regions. Cushman (1944) found it in Vineyard sound at 20 m, south of middle ground, and 24 m off Lamberts cove. Said (1949) found it as a common species in the shallower areas of the Gulf of Suez and Coral reef of the Red Sea at 59 to 103 m depth range. Parker (1954) reported less than 1% of E. advenum at less than 115 m depth from north-eastern Gulf of Mexico and (Parker, 1958) upto 2% occurrence at 9 stations from bay environment at 179 m depth from eastern Mediterranean Sea. Todd and Bronnimann (1957) noted its frequent distribution from nearshore (0 to 4 m) and offshore zones (23 to 33 m) of Gulf of Paria. Todd and Low (1961) recorded E. advenum from harbours and inlets of Martha, Vineyard Island, USA, in 20 to 21°C temperature and 30.6 to 31.6 ‰ salinity ranges. Uchio (1962) encountered its 15% occurrence at Wakaura beach and 2 to 9% from Mori Harbour along the coast of Wakayama-Ken, Japan. Ishiwada (1964) reported E. advenum from off Kushira and Erimosaki (22 to 120 m), off Hachinohe to Inubo-saki (64 to 133 m) and Tosa Bay (56 to 280 m), off the Pacific coast of Japan. Betjeman (1969) noted frequent occurrences of this species from west Australian shelf and grouped it under species of tropical-subtropical faunal regions. Matoba (1970) recorded it as member of middle and outer bay facies from Matsushima Bay, north-east Japan. Akpati (1975) recorded E. advenum at 10 to 20 m depth and 29 to 30‰ salinity from eastern long Island Sound, New York.

E. advenum widely occurs along the east and west coasts of India. From the east coast, Bhatia and Bhalla (1964) reported it from Puri beach; Bhalla (1968) from Vishakhapatnam beach; Rao and Rao (1974) from Suddagedda estuary near Vishakhapatnam with substrate having 0.66% organic matter; and Reddy and Rao (1980) from Pennar estuary, Andhra Pradesh. From the west coast, Bhatia (1956) reported it from Juhu beach sand, Bombay;

Sethulekshmi Amma (1968) from Travancore coast; Rocha and Ubaldo (1964a,b) from Gogola, Simbor and Baga beaches; Antony (1968) from Kerala coast at 46 to 183 m depth range; Rao (1971b) from north-eastern part of Arabian sea; and Seibold (1975) from lagoon and off-shore region of Cochin.

Summary of ecological data: Depth upto 183 m, temperature 20 to 21°C, salinity 30.6 to 31.6 ‰.

Repository of type material: AMUGD cat. No. MF 265.

Elphidium craticulatum (Fichtel and Moll)

Plate 6, figure 7.

Nautilus craticulatus FICHTEL and MOLL, 1798, p. 51, pl. 5, figs. h-k.

Polystomella craticulata BRADY, 1884, p. 739, pl. 110, figs. 16-17.

Elphidium craticulatum (Fichtel and Moll).- CUSHMAN, 1933, p. 48, pl. 11, figs. 5a-b.- BHATIA, 1956, p. 20, pl. 5, fig. 10.- GANAPATI and SATYAVATI, 1958, p. 115, pl. 3, figs. 87-88.- GANAPATI and SAROJINI, 1959, p. 312.- ROCHA and UBALDO, 1964a, p. 10, pl. 3, fig. 7; 1964b, p. 647, pl. 1, fig. 3.- ANTONY, 1968, p. 61, pl. 4, fig. 3.- RAO, VEDANTAN and RAO, 1979, p. 360.

Dimensions (in mm): Major diameter 0.39 to 0.48, minor diameter 0.35 to 0.4, thickness 0.19 to 0.21.

Remarks: E. craticulatum is a typical Indo-Pacific species. Norton (1930) found its common occurrence from Murray Island, Australia, at 0.3 to 0.5 m depth and 23.0 to 28.8°C temperature range. Uchio (1962) recorded E. craticulatum from Wakaura, Nishihiro, Seto, and Kuhsimoto beaches along the coast of Wakayama-Ken, Japan.

From Indian waters, Ganapati and Satyavati (1958) recorded it from Vishakhapatnam coast in 70 to 73 m depth and 20.65 to 24.99°C temperature ranges; Rao *et al.* (1979) at 55 to 105 m and 165 to 190 m depth ranges from shelf off Vishakhapatnam east coast. From the west coast, *E. craticulatum* has been reported by Bhatia (1956) from Bhogat beach; Rocha and Ubaldo (1964a,b) from Jampore, Damao, Diu and Gogola beaches; Antony (1968) from Kerala coast at 23 to 183 m depth range; and Nigam *et al.* (1979) from shelf region off Ratnagiri at 15 to 50 m depth range.

Summary of ecological data: Depth upto 190 m and temperature 20.5 to 28.8°C.

Repository of type material: AMUGD cat. No. MF 266.

Elphidium crispum (Linne')

Plate 6, figure 2.

Nautilus crispum LINNE', 1758, p. 709.

Elphidium crispum (Linne') CUSHMAN and GRANT, 1927, p. 73, pl. 7, figs. 3a-b.- BHATIA, 1956, pl. 5, figs. 11a-b.- SETHULEKSHMI AMMA, 1958, p. 22, pl. 1, fig. 33.- ROCHA and UBALDO, 1964a, p. 10, pl. 3, fig. 8.- ANTONY, 1968, p. 60, pl. 3, fig. 27.- BHALLA, 1968, pp. 385-386, pl. 2, fig. 4a-b; 1970, pp. 158-159, pl. 21, figs. 1a-b.- RAO, 1970b, p. 264, pl. 4, fig. 46, SEIBOLD, 1975, p. 195.- BHATIA and KUMAR, 1976, p. 242.- RAO, VEDANTAM and RAO, 1979, p. 357.- NIGAM, SETTY and AMBRE, 1979, p. 246.- REDDY and RAO, 1980, p. 169, pl. 6, figs. 1-2.

Dimensions (in mm): Major diameter 0.31 to 0.45, minor diameter 0.31 to 0.35, thickness 0.20 to 0.22.

Remarks: E. crispum is one of the widely recorded and, perhaps, the best studied species of Elphidium commonly found in shallow, turbulent, waters of the different parts of the world. It is known to tolerate wide range of salinity and temperature fluctuations. Cushman and McCulloch (1940) noted 4 to 240 m depth range for E. crispum. Said (1949) recorded it at

17.59 m depth from Gulf of Suez and Red Sea; Colom (1950) from 726 m depth off the coast of Africa, Parker (1958) at 11 to 21°C temperature and 38 to 39 ‰ salinity ranges at less than 25 m depth from Mediterranean; Uchio (1962) reported E. crispum from Wakaura, Shiraki, Nishihiro, Seto, and Kushsimoto beaches and at one station of Mori harbour (1% at 7 m depth) along the coast of Wakayama-Ken, Japan. Murray (1963), studied this species in laboratory culture and observed that it does not prefer a clay substratum, with decrease in salinity, the feeding rate also decreases; and it can survive in sub-saline water if the temperature is low. Myers (1943) showed that E. crispum is a "hard" foraminifer as it can remain buried for 2 to 3 months under as overburden of 1 cm of sediment and can still remain alive. Matoba (1970) encountered it from Matsushima Bay, north-east Japan and observed common occurrence in the outer bay facies, while rare in middle bay facies. Haman (1971) showed occurrence of living specimens of E. crispum from Tremador Bay, North Wales, U. K., but he did not find any living specimen of this species below 25‰ salinity. Lankford and Phleger (1973) showed its occurrence from near shore turbulent zone, West North America, where it prefers 0 to 30 m depth range and rockey-sandy substrate. Scott *et al.* (1976) recorded living specimens of *E. crispum* at 24 m depth and 31 to 35 ‰ salinity range from San Diago Bay. *E. crispum* is known from both the east and west coasts of India. Bhalla (1968, 1970) reported it from Marina and Vishakhapatnam beaches; Rao *et al.* (1979) from shelf off Vishakhapatnam at 20 to 190 m depth range and Reddy and Rao (1980) from Pennar estuary from the east coast; while Bhatia (1956), Sethulekshmi Amma (1958), Rocha and Ubaldo (1964a, 1964b), Antony (1968), and Rao (1970b) described it from the west coast. Bhatia and Kumar (1976) encountered this species from Anjidiv Island near Karwar at 5 to 15.4 m depth, 29 to 30.1°C temperature and 33.49 to 35.01 ‰ salinity ranges. Ujiie (1956) made a study of the internal character of the test of *E. crispum* (as discussed in Remarks on *E. advenum*).

The Geological ranges of this species is from Miocene to Recent.

Summary of ecological data: Depth upto 726 m, temperature 11 to 30.0°C, salinity 25 to 38.39 ‰.

Repository of type material: AMUGD cat. No. MF 267.

Elphidium discoidale multiloculatum Cushman and Ellisor.
Plate 6, figure 5.

Elphidium discoidale (D'orbigny) var. *multiloculatum* CUSHMAN and ELLISOR, 1945, p. 561, pl. 75, fig. 92.

Elphidium discoidale multiloculatum BHATIA and KUMAR, 1976, p. 249, pl. 2, figs. 12-13.

Dimensions (in mm): Major diameter 0.40 to 0.51, minor diameter 0.42 to 0.45, thickness 0.17 to 1.90.

Remarks: Bhatia and Kumar (1976) recorded *E. discoidale multiloculatum* for the first time from Indian waters, innershelf area off Bingi Bay, Anjidiv Island, near Karwar, at 6 to 14.5 m depth, 28.5 to 30.1°C temperature, 8.7 to 10.1 pH, 33.49 to 34.65 ‰ salinity and 4.31 to 4.92 ml/l dissolved oxygen ranges and noted, "It is closely related to *E. advenum* (Cushman) from which it differs in lacking the peripheral keel, in having 16 to 18 chambers and low transparent umblical knob with perforation and showing the earlier whorls (cf. *cellanthus*)" (Bhatia and Kumar, *op. cit.*, p.243)

Repository of type material: AMUGD cat. No. MF 268.

Elphidium indicum Cushman.

Plate 6, figure 3.

Elphidium indicum CUSHMAN, 1936, p. 83, figs. 10a-b.- BHATIA, 1956, p. 20, pl. 5, figs. 1 and 5.- ROCHA and UBALDO, 1964a, p. 417, pl. 5, figs. 2a-b, 1964b, p. 647, pl. 1 figs. 6-7,- BHALLA, 1968, p. 386, pl. 2, figs. 7a-b.- BHATIA and KUMAR 1976, p. 242, NIGAM, SETTY and AMBRE, 1979, p. 245.

Dimensions (in mm): Major diameter 0.50 to 0.60, minor diameter 0.44 to 0.50, thickness 0.26 to 0.27.

Remarks: Elphidium indicum has been reported from the west coast of India by Bhatia (1955) from Juhu, Chowpatty and Bhogat beaches; Rocha and Ubaldo (1964a,b) from Gogola and Jampore beaches; Bhatia and Kumar (1976) from Anjidiv Island near Karwar at 5 to 10.5 m depth, 28.7° to 30.1°C temperature and 8.7 to 9.8 ‰ salinity range; Nigam et al. (1979) from inner-shelf off Ratnagiri at 15 to 50 m depth range. Bhalla (1968) recorded it from Vishakhapatnam beach sands, east - coast of India.

Repository of type material: AMUGD cat. No. MF 269.

Elphidium macellum (Fichtel and Moll)

Plate 6, figure 8.

Nautilus macellus FICTHEL and MOLL, 1798, p. 66, var. β, pl. 10, figs. h, k.

Elphidium macellus (Fichtel and Moll).- MONTFORT, 1808, p. 15, 4 genre.- ANTONY, 1968, p. 63, pl. 3, fig. 28.

Dimensions (in mm): Major diameter 0.38, minor diameter 0.35, thickness 0.167.

Remarks: Cushman (1939) illustrated and summarised the distribution of *E. macellum* in various parts of the world. Norton (1930) recorded *E. macellum* (= E. macellus) from Floridian and West Indies region in 0.5 to 29 m depth, 21.5 to 31.4°C temperature ranges. Atkinson (1971) found empty tests of this species in turbulent zone, Cardigan Bay, at all depths. Haman (1971) recorded this species from "Hollow" environment at 33.5 to 34.0 ‰ salinity range with the sediments varying from silty mud to very fine sand, composed of 40 to 70% quartz, 30 to 40% lithoclasts and 30 to 50% bioclasts.

From Indian waters, Antony (1968) reported *E. macellum* from 3 traverses-Trivandrum, Quilon and Cochin-off Kerala Coast in 27 to 146 m depth range.

Summary of ecological data: Depth upto 146 m, temperature 21.5 to 31.4°C and salinity 33.5 to 34.0 ‰.

Repository of type material: AMUGD cat. No. MF 270.

Elphidium minutum (Reuss)

Plate 6, figure 6.

Polystomella minuta.- REUSS, 1864, p. 478, pl. 4, figs. 6a-b.

Polystomella discrepans REUSS, 1864, p. 478, pl. 4, figs. 7a-b.

Elphidium minutum (Reuss).- CUSHMAN, 1939, p. 40, pl. 10, figs. 22-25.- BHALLA, 1968, p. 386, pl. 2, figs. 6a-b; 1970, p. 159, pl. 21, figs. 2a-b.- NIGAM, SETTY and AMBRE, 1979, p. 245.

Dimensions (in mm): Major diameter 0.33 to 0.55, minor diameter 0.28 to 0.30, thickness 0.13 to 0.16.

Remarks: The types of E. minutum are from Late Oligocene of Germany. It was recorded by Bhalla (1968, 1970) from sandy beaches of Vishakhapatnam and Marina along the east coast of India. Recently, Nigam et al. (1979) recorded it from inner-shelf (15 to 50 m depth) off Ratnagiri, west coast of India.

Repository of type material: AMUGD cat. No. MF 271.

<u>*Elphidium simplex*</u> Cushman

Plate 6, figure 9.

<u>*Elphidium simplex*</u> CUSHMAN, 1933, p. 52, pl. 12, figs. 8-9.- BHATIA, 1956, p. 20, pl. 5, fig. 13.- BHATIA and BHALLA, 1964, p. 79, pl. 1, figs. 7a-b.- ROCHA and UBALDO, 1964a, p. 417, pl. 5, figs. 2a-b.- BHALLA, 1968, p. 386, pl. 2, figs. 6a-b.- RAO, 1971b, p. 159, fig. 38.- RAO and RAO 1974, pl. 3, figs. 5a-b.- BHATIA and KUMAR, 1976, p. 249.- REDDY and RAO, 1980, p. 168, pl. 6, fig. 6.

<u>Dimensions (in mm)</u>: Major diameter 0.28, minor diameter 0.23, thickness 0.15.

<u>Remarks</u>: Cushman and McCulloch (1940) noted the occurrence of <u>*E. simplex*</u> at Gaviota Pier, off California coast at 15 m; Morro Bays at 4 m; off the Central Island at 4-82 m; in the Gulf of California at 15 m; off Central America and Galapagos at 4 to 27 m.

<u>*E. simplex*</u> is known from both the coasts of India. From the west coast, it was reported by Bhatia (1956) from Juhu beach sands, Bombay; Rocha and Ubaldo (1964a) from Diu, Gogola, Simbor beaches; Rao (1971b) from north-eastern part of the Arabian sea at 27 m depth in muddy substrate and rarely at 64 m depth in sandy

substrate; Bhatia and Kumar (1976) from a station in Binge Bay, Anjidiv Island, near Karwar, at 5 m depth, 30.1°C temperature, 8.7 pH, 34.56 ‰ salinity and 4.31 ml/l dissolved oxygen. From the east coast, it was encountered by Bhatia and Bhalla (1964) from Puri beach sand; Bhalla (1968) from Vishakhapatnam beach sand; and Reddy and Rao (1980) from Pennar estuary, Andhra Pradesh.

Summary of ecological data: Depth upto 82 m, temperature 30.1 to 34.0°C, salinity 34 to 35 ‰.

Repository of type material: AMUGD cat. No. MF 272.

<u>Elphidium</u> sp.

Plate 6, figure 10.

<u>Dimension (in mm)</u>: Major diameter 0.28, minor diameter 0.22, thickness 0.10.

<u>Remarks</u>: A few minute and worn out specimens of <u>Elphidium</u> occur in Juhu beach sands which could not be identified at species level. However, well-preserved specimens are required for the proper identification of the species.

<u>Repository of type material</u>: AMUGD cat. No. MF 273.

Genus <u>CRIBROELPHIDIUM</u> Cushman and Bronnimann, 1948.

<u>Cribroelphidium</u> sp.

Plate 6, figure 12.

<u>Dimensions (in mm)</u>: Major diameter 0.40, minor diameter 0.33, thickness 0.16.

<u>Remarks</u>: A solitary specimen of <u>Cibroelphidium</u> was found in our material from Karwar beach. This specimen belongs to <u>Cribroelphidium</u> Cushman and Bronnimann, 1948, but some more specimens are needed before it can be identified at species level.

<u>Repository of type material</u>: AMUGD cat. No. MF 274.

Genus PROTELPHIDIUM Haynes, 1956.

Protelphidium aff P. granosum (D'orbigny)

Plate 6, figure 11.

Protelphidium granosum (D'orbigny) LUTZE, 1974, pl. 9, figs. 135-138.- SEIBOLD, 1975, p. 197, pl. 2, fig. 5.

Dimensions (in mm): Major diameter 0.21, minor diameter 0.18, thickness 0.10.

Remarks: A few specimens of Protelphidium were encountered in our material from Juhu beach which show close affinity with P. granosum. Seibold (1975) recorded this species from offshore region of Cochin.

Repository of type material: AMUGD cat. No. MF 275.

4.3.16 Family NUMMULITIDAE De Blainville, 1825.

Subfamily NUMMULITINAE De Blainville, 1825.

Genus NUMMULITES Lamark, 1801.

Nummulites ammonoides (Gronovius)

Plate 7, figure 8.

Nautilus ammonoides GRONOVIUS, 1781, p. 282, pl. 19, figs. 5-6.

Operculina gaimardi D'orbigny, 1826, p. 281.

Operculina ammonoides (Gronoviues) CARPENTER, PARKER and JONES, 1862, p. 310.- ANTONY, 1968, p. 65, pl. 4, fig. 8.-
Nummulites ammonoides.- RAO, VEDANTAM and RAO, 1979, p. 367.

Dimensions (in mm): Diameter 0.59 to 0.61, thickness 0.23 to 0.24.

Remarks: Nummulites ammonoides has been recorded by several authors from different parts of the Indo-Pacific region. Graham and Militante (1959) recorded it from Puerto Galera Bay, Phillippines at 27 m depth, 33.5 ‰ (surface) and 34.5 ‰ (bottom) salinities, and 25.9°C temperature and also Balateros region at 22 m depth, 33.5 ‰ (surface) and 34.5 ‰ (bottom) salinities and 27.36°C (bottom) and 27.85°C (surface) temperature ranges.

From Indian waters, Antony (1968) described N. *ammonoides* (= *Operculina ammonoides*) from Kerala coast in 22 to 91 m depth range. Recently, Rao *et al.* (1979) obtained it from 20 to 183 m depth from the shelf region off Vishakhapatnam, east coast of India.

Summary of ecological data: Depth upto 91 m, temperature 25.9 to 27.8, and salinity 33.5 to 34.5 ‰.

Repository of type material: AMUGD cat. No. MF 276.

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862.

4.3.17 Family GLOBOROTALIIDAE Cushman, 1927a.

Subfamily GLOBOROTALIINAE Cushman, 1927a.

Genus GLOBOROTALIA Cushman, 1927a.

Globorotalia cultrata cultrata (D'orbigny)

Plate 5, figure 6.

Rotalina (Rotalina) cultrata D'ORBIGNY, 1839.

pl. 5, figs. 7-9.

Globorotalia cultrata cultrata (D'orbigny).- BLOW, 1969, pl. 6, figs. 4-8.- ZOBEL, 1971, p. 1331, pl. 1, figs. 1-3; 1973, pl. 3, figs. 1-3.-FLEISHER, 1974, pp. 1025-1026.

Dimensions (in mm): Length 0.40, width 0.30, thickness 0.30 .

Remarks: Zobel (1971, 1973) recorded G. cultrata cultrata from Arabian Sea along Indian and African Coasts and noted (Zobel, 1971, p. 1331).".... dominant species in the north-western Arabian Sea where it is nearly missing in the north of the Indian area. Moreover, this species has corresponding maxima off the Indian and off the African continental slope, again flanked by about the same isotherms on either side". Fleisher (1974) recorded Globorotalia cultrata cultrata from deep sea drilling site 219, off Cochin, India, and 223, off Arabia, and also made certain valuable ecological comments on G. cultrata and allied species.

Repository of type material: AMUGD cat. No. MF 277.

4.3.18 Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862.

Subfamily GLOBIGERININAE Carpenter, Parker and Jones, 1862.

Genus GLOBIGERINA D'orbigny, 1826.

Globigerina bulloides D'orbigny

Plate 5, figure 7.

Globigerina bulloides D'ORBIGNY, 1826, p. 277.- BRADY, 1884, p. 593, pl. 77, figs. 3-7.- SETHULEKSHMI AMMA, 1958, p. 12, pl. 1, figs. 20 a-b.- GANAPATI and SATYAVATI, 1958, p. 116, figs. 142-146.- GANAPATI and SAROJINI, 1962, p. 312.- ANTONY, 1968, p. 104, pl. 7, figs. 13a-b.- ZOBEL, 1971, p. 1326, pl. 1, figs. 8-9.- RAO, 1971a, p. 11, figs. 74a-b; 1972, p. 2, fig. 16; 1973, p. 55.- SETTY, 1972, p. 132, pl. 1, figs. 1-2.- SETTY and GUPTHA, 1972, p. 152, pl. 22, figs. 1-2.- GUPTHA, 1973b, p. 147.

Dimensions (in mm): Diameter 0.25 to 0.33, thickness 0.18.

Remarks: G. bulloides is abundant in subarctic and transitional waters and is practically absent in tropical and sub-tropical waters, South of 40°E.

However, it is found in the present warm, tropical water assemblage which is probably due to transportation of empty tests. From the east coast of India, Ganapati and Satyavati (1958) reported G. bulloides from 49 stations at 9 m to 304 m depth and 11.67 to 28.33°C temperature ranges and Ganapati and Sarojini (1962) from Vishakhapatnam coast. From the west coast, this species has been reported by Antony (1968) from Kerala Coast at 10 to 100 m depth range; Zobel (1971) from Arabian Sea with maximum concentration near Cochin; Setty (1972) from shelf sediments, off Kerala Coast; Setty and Guptha (1972) from inner neritic and outer slope regions, off Karwar and Mangalore coasts at 31 to 201 m depth, 28.3 to 29.5°C (surface) and 14.31 to 28.02°C (bottom) temperatures and 33.2 to 36.28 ‰ salinity ranges within silty sand and clayey silt substrate. Rao (1971a) recorded it from Gulf of Cambay with muddy-sand substrate and the same author (Rao, 1972) from eastern Arabian sea in 64 to 820 m depth range; Guptha (1973b) found it along south-west coast of India with maximum concentration near Alleppey in Kerala. This species ranges from Cretaceous to Recent.

Repository of type material: AMUGD cat. No. MF 278.

Genus GLOBIGERINOIDES Cushman, 1927.

Globigerinoides ruber (D'orbigny)

Plate 5, figure 8.

Globigerina ruber D'ORBIGNY, 1939, p. 82, pl. 4, figs. 12-14.- BRADY, 1884, p. 602, pl. 79, figs. 11-16.

Globigerinoides rubra (D'orbigny) CUSHMAN, 1927a, p. 87.- GANAPATI and SATYAVATI, 1958, p. 117, pl. 6, figs. 149-150.- ANTONY, 1968, p. 107, pl. 7, figs. 16a-b.

Globigerinoides ruber PARKER, 1962, p. 230, pl. 3, figs. 11-14, pl. 4, figs. 1-10.- RAO, 1971b, pl. 161, fig. 54; 1972, p. 2, fig. 11; 1973, p. 56.- ZOBEL, 1971, p. 1331, pl. 1, figs. 11-13.- SETTY, 1972, p. 133, pl. 1, figs. 17-18.- SETTY and GUPTHA, 1972, p. 155, pl. 22, figs. 5-6.- GUPTHA, 1973b, p. 148.

Dimensions (in mm): Length 0.50 to 0.65, width 0.39 to 0.41, thickness 0.30 to 0.38.

Remarks: Globigerinoides ruber is characterised by its supplementary apertures found around the margin of the last-formed chamber and coarsely pitted nature of the test. Specimens encountered in the present material resemble *G. ruber* as described and figured by Graham and Militante (1959).

G. ruber is commonly found in tropical and sub-tropical waters on the west coast of India. According to Zobel (1971), it decreases generally from North to South. It is the absolutely dominant species in the North-eastern part of the Arabian Sea but does not gain dominance in its North-west part. From the west coast of India, Antony (1968) described this species from Kerala coast at a depth of 82 to 183 m depth and Setty and Guptha (1972) reported it from Karwar and Mangalore areas at 654 to 661 m depth, 28.30 to 29.5°C surface temperature, 14.31 to 28.22°C bottom temperature, 33.28 to 35.79 ‰ salinity and 0.22 to 4.32 ml/l oxygen range. From the east coast, Ganapati and Satyavati (1958) reported it from near Vishakhapatnam at 40 to 300 m depth and 13.89 to 26.67°C temperature range.

Repository of type material: AMUGD cat. No. MF 279.

Genus, GLOBOQUADRINA Finlay, 1947.

Globoquadrina dutertrei (D'orbigny)
Plate 5, figure 9.

Globigerina dutertrei D'ORBIGNY 1839, p. 84.

Globoquadrina dutertrei.- RAO, 1971b, p. 161; 1972, p. 2, pl. 1, fig. 21.- RAO, 1973, p. 57.- SETTY and GUPTHA, 1972, pp. 156-157, pl. 23, figs. 1-3.- GUPTHA, 1973b, p. 148; 1975, p. 8, pl. 2, figs. 14-15.

Dimensions (in mm): Diameter 0.28, thickness 0.22.

Remarks: Parker (1962) found G. dutertrei at north of latitude 45°S in South Pacific sediments. She summarised the work of different authors and gave distribution of G. dutertrei in modern oceans. Berger (1971) found rare specimens of this species from off Baja California and Mexico and observed that the majority of specimens were environmentally stressed individuals. G. dutertrei is common in transitional subtropical and tropical waters of the Atlantic and Pacific oceans (Be' and Hamlin, 1967). Hech and Savin (1972) made isotopic analysis of G. dutertrei sp. and found that no isotopic temperature was observed between the phenotype of the Atlantic and Pacific samples".

Jenkins (1973) recorded _G. dutertrei_ as subtropical and tropical member from Cenozoic formation of New Zealand. Rao (1971b) found _G. dutertrei_ from the north-eastern part of the Arabian Sea, occurring abundantly in 67 to 97 m depth range in muddy sand or sandy substrate and rare at 16 to 27 m depth in muddy substrate; Rao (1972) from the eastern Arabian Sea at 62 to 1460 m depth; Rao (1973) from South-west Arabian Sea at 62 to 960 m depth; Zobel (1971, 1973) recorded this species as _Neogloboquadrina dutertrei_ (D'orbigny) from Arabian Sea; Setty and Guptha (1972) reported it from sediments off Karwar and Mangalore areas at 18 to 196 m depth, 28.3 to 29.5°C (surface) and 14.3 to 28.27°C (bottom) temperature and 0.22 to 4.32 ml/l oxygen ranges; and Guptha (1973b) found it at 31 to 212 m depth off Cochin; and (Guptha 1974) at 800 to 1740 m depth off Bombay. _G. dutertrei_ has also been reported from Andaman Sea, Bay of Bengal at 14 to 3778 m by Frerichs (1971).

Repository of type material: AMUGD cat. No. MF. 280.

Superfamily ORBITOIDACEA Schwager, 1876.

4.3.19 Family EPONIDIDAE, Hofker, 1951.

Genus EPONIDES Montfort, 1808.

Eponides repandus (Fichtel and Moll)

Plate 7, figure 1.

Nautilus repandus FICHTEL and MOLL, 1798, p. 34, pl. 3, figs. a-d.

Eponides repandus (Fichtel and Moll) CUSHMAN, 1931, p. 49, pl. 10, figs. 7a-c.- CHAUDHARY and BISWAS, 1954, p. 81.- SETHULEKSHMI AMMA, 1958, p. 72, pl. 3, figs. 111a-b.- ROCHA and UBALDO, 1964a, p. 414, pl. 2., figs. 111a-b.- ROCHA and UBALDO, 1964a, p. 414, pl. 2., figs 10a-b; 1964b, p. 647, pl. 1, figs. 8-9.- RAO, 1971b, p. 160, fig. 51.- ZOBEL, 1973, p. 15, pl. 2, fig. 59.- VENKATACHALAPATHY and SHAREEF, 1976, pp. 375.- 378, pl. 1, figs. 4a-c.- REDDY and RAO, 1980, p. 169, pl. 5, figs. 11-12.

Dimensions (in mm): Length 0.38 to 0.45, width 0.32 to 0.36, thickness 0.23 to 0.25.

Remarks: *E. repandus* is a cosmopolitan species. Norton (1930) found frequent to rare specimens of

E. repandus from Florida and West Indian region at 0.3 to 201 m depth and 20°C to 29°C temperature ranges; Said (1949) from Gulf of Suez and Red Sea from 64 to 400 m depth range. Drooger and Kaasschieter (1958) recorded it from Trinidad Paria shelf in 20 to 40 m depth; Graham and Militante (1959) from Phillipines at 25 m depth, 31.0 to 34.5 ‰ surface and 33.0 to 34.5 ‰ bottom salinity ranges and 26.5 to 28.75°C surface and 25.98 to 28.49°C bottom temperature ranges. Parker (1954) reported it from Gulf of Mexico at 185 m depth and Hofker (1971) recorded its rare occurrence from Piscadera Bay at 1 to 4 m depth range in sandy substrate.

From Indian waters, *E. repandus* has been reported by Chaudhary and Biswas (1954) from Juhu beach, Bombay; Rocha and Ubaldo (1964a) from Diu, Gogola and Simbor beaches; Sethulekshmi Amma (1958) from Travancore coast; Rao (1971b) from north-eastern part of Arabian sea at a depth of 64 m and 27.71°C surface temperature in sandy substrate; Rao and Rao (1979) from nearshore water off Trivandrum on the west coast of India. From the east coast, Reddy *et al.* (1980) recorded it from Pennar estuary of Andhra Pradesh.

Summary of ecological data: Upto 400 m, temperature 20 to 29°C, salinity 30.0 to 34.5 ‰.

Repository of type material: AMUGD cat. No. MF 281.

Genus POROEPONIDES Cushman, 1944

Poroeponides cribrorepandus Asano and Uchio

Plate 7, figures 2, 3

Poroeponides cribrorepandus (Asano and Uihio)

ASANO, 1951, p. 18, figs. 134-134.- TODD, 1957, p. 290, (Table), pl. 93, figs. 9a-c.- GRAHAM and MILITANTE, 1959, p. 96, pl. 14, figs. 8a-c.

Dimensions (in mm): (a) Megalospheric - Length 0.48 to 0.53

Width 0.40 to 0.43

Thickness 0.25 to 0.26

(b) Microspheric - Length 0.52 to 0.56

Width 0.42 to 0.44

Thickness 0.26 to 0.28

Remarks: *P. cribrorepandus* was originally described from Pliocene of Japan and this is the first report of this species from Indian waters. Todd (1965) considered

Poroeponoides cribrorepandus and *P. letaralis* as junior synonyms of *E. repandus*. Taxonomic relationships between *Eponodes rependus*, *Poroeponides cribrorepandus*, *P. lateralis* has been discussed by Nigam (1978). In ecological tolerance *P. cribrorepandus* resembles *E. repandus* discussed earlier. Uchio (1962) found rare specimens of *P. cribrorepandus* from Shiraki, and Kushimoto beach sands along the coast of Wakayama-Ken, Japan. Matoba (1970) encountered this species in 2.7 to 12.5 m depth range as a member of outer bay facies from Matsushima Bay, north-east Japan; Akpati (1975) recorded living specimens of this species at a depth 8 m, while dead specimens were found at 8 to 20 m depth range from eastern Long Island Sound, New York. In present assemblage both, microspheric and megalospheric generations are present.

Repository of type material: AMUGD cat No. MF 282.

Porceponides lateralis (Terquem)

Plate 7, figure 4.

Rosalina lateralis TERQUEM, 1878, p. 25, pl. 2, fig. 11.

Poroeponides lateralis (Terquem) CUSHMAN, 1944, p. 34, pl. 4, fig. 2.- BHATIA, 1956, p. 23, pl. 3, figs. 3-5.- BHATIA and BHALLA, 1964, p. 80, pl. 2, figs. 3a-b,- ROCHA and UBALDO, 1964a, p. 415, pl. 2, fig. 11; 1964b, p. 647, pl. 1, figs. 11, 15.- BHALLA, 1968, p. 387, pl. 2. figs. 8a-b; 1970, p. 160, pl. 21, figs. 6a-b.- BHATIA and KUMAR, 1976, p. 242.- VENKATACHALAPATHY and SHAREEF, 1976, pp. 378-379, pl. 1, figs. 5a-b.

Dimensions (in mm): Length 0.78 to 0.79, width 0.59 to 0.61.

Remarks: Poroeponides lateralis is a well-known cosmopolitan species and shows wide range of morphological variation. It is commonly recorded from shallow, warm waters of tropical and sub-tropical areas. Due to thick test, the species is able to withstand abrasion and consequently, frequently occurs in shore sands. Cushman (1944) found it as a very common species in Buzzard Bay (18 to 23 m) and in Vineyard sound (11 to 24 m) along new England coast; Todd and Low (1961) recorded it from open sea beaches facing Atlantic ocean (temperature 19 to 23°C and salinity 31.3 to 32.1 ‰) and banks facing Vineyard Sound (temperature 19 to 20°C, salinity 31.1 to 31.6 ‰) near Vineyard Island, Massachusetts; and Matoba (1970) found P. lateralis at only one station (5.7 m depth in Matsushima Bay, north-east Japan. Seiglie (1970, p. 189) recovered specimens of this species from Yabucoa Bay, South-east Puerto Rico, and noted, "Poroeponides lateralis (Terquem), a reef stenohaline species has been found alive in station 4b close to the mouth of Yabucoa river". Temperature in the area varies from 25 to 26°C and salinity 34 to 35‰ during dry season.

From the east coast of India Bhalla (1968) recorded P. lateratis from Vishakhapatnam beach sands; Bhatia and Bhalla (1964) from Puri beach and Reddy and Rao (1980) from Pennar estuary, Andhra Pradesh and from the west coast, this species has been reported by Bhatia (1956) from Juhu, Chowpatty and Bhogat beaches; and Rocha and Ubaldo (1964a,b) from Gogola, Simbor and Baga beaches. Bhatia and Kumar (1976) described it from Anjidiv Island, near Karwar, in 5 to 10 m depth, 28.7 to 30.1°C temperature, and 33.49 to 34.01‰ salinity ranges.

Summary of ecological data: Depth upto 24 m, temperature 19.0 to 30.1°C, salinity 31.1 to 34.01 ‰.

Repository of type material: AMUGD cat. No. MF 283.

4.3.20 Family AMPHISTEGINIDAE Cushman, 1927.

Genus AMPHISTEGINA D'orbigny, 1846.

Amphistegina madagascariensis D'orbigny
Plate 7, figure 9

Amphistegina madagascariensis D'ORBIGNY, 1826, p. 304.- BHALLA, 1970, p. 160, pl. 21, figs. 7a-c.- GUPTHA, 1973a, p. 781.

Dimensions (in mm): Length 0.72 to 0.75, width 0.62 to 0.64, thickness 0.36 to 0.37.

Remarks: A. madagascariensis is considered to be an Indo-Pacific species. Todd (1965) demonstrated that it varies with environments. In beach and nearshore environment, thicker tests are more common while specimens from lagoons show large and compressed tests with well-marked sutures. She (Todd, 1976, p. 382 Abs) made a detailed study of the genus Amphistegina and noted, "Amphistegina should not be separated from Asterigerina on the basis of wall structure as has been done, but they can be maintained as separate genera on the basis of morphology". She (Todd, op. cit. p. 390) also summarised work on the ecology of A. madagascariensis by several workers, Fornasini, 1903, Cushman, Todd and Post 1954, Mckee, Chronic and Leopold, 1959, (Todd, 1965, Blanc Vernet 1969, Todd and Low 1970 and others) and concluded, "It seems clear that morphological variation with in fossil specimens of _A. madagascariensis_ may be used for interpreting the conditions under which the species lived, whether on the reef or in the lagoon. It is also seems clear that the occurrence of the species _A. madagascariensis_, _A. radiate_, and _A. lessonii_ may be used for deducing the depth and location of deposition - shallow and reef or lagoonal for the former and deep lagoonal and outer slope or guyot for the latter too. Furthermore, we may speculate that fragile, complanate tests imply deeper sites more distant from shore than do the thick, heavy walled test that would be more suitable to withstand the turbulence of surf and currents".

"Most specimens of _Amphistegina madagascarensis_ show a greenish or brownish tint while living. The normal colour of empty test of this species is orange for specimens from reef surface and white for specimens from moderate depths in lagoonal or reef front".

"Thus we may assume that the floating ability of _Amphistegina madagascarensis_, either by suspension from its extended pseudopods or by the adherence of its pseudopods to sand grains or organic fragments which may themselves be transported by floatation, provides this species with an easy mean of dispersal".

From the Indian region, Bhalla (1970) recorded *A. madagascarensis* from Marina beach sand, Madras, and Guptha (1973a) from lagoonal sediments of Kavaratti Atoll, Laccadives, at 4 m maximum depth, 30.6 to 32.5°C bottom water temperature and 33 to 53 ‰ salinity ranges.

Repository of type material: AMUGD cat. No. MF 284.

Amphistegina radiata (Fichtel and Moll)

Plate 7, figure 7.

Nautilus radiatus FICHTEL and MOLL, 1798, p. 58, pl. 8, figs. a-d.

Amphistegina radiata (Fichtel and Moll)- CHAPMAN, 1895, p. 45, pl. 1, figs. 8-10.- ROCHA and UBALDO, 1964a, p. 417, pl. 4, figs. 1a-b.

Dimensions (in mm): Length 0.52 to 0.54, width 0.49 to 0.51, thickness 0.22 to 0.24.

Remarks: A. radiata is a warm, shallow-water, species. Said (1949) recorded this species in 17 to 941 m depth range from coral reef area of the Red Sea and noted that specimens procured from shallow-water stations are smaller than those found at the deeper water stations. Graham and Militante (1959) recorded it from Puerto Galera area, Phillipines, at 5.5 to 25.5 m depth, 33.5 (surface) to 34.50 ‰ (bottom) salinities, and 25.28 (bottom) to 28.29°C (surface) temperature ranges. Todd (1965) observed that it is much distributed in deeper water. She also studied the morphological variation and differences with allied species. In her subsequent publication, Todd (1976, p. 387) noted it, "Is a much more delicate species found in deeper water more than 35 m and does not constitute predominant part of the assemblages. It is extremely variable in size, shape, and ornamentation or lack of it. The species can be distinguished in general form *A. madgascarinsis* by the fact that it is more compressed, more equally biconvex, with its plane of coiling flat instead of boweel up dorsally, and has limbate ridge and knob of glassy shell material which in some specimens make the suture more distinct and in other constitute a surface wall ornamented that obscures the position of the surfaces". Hofker (1969, p. 81) observed, "*A. radiata* is a circum tropical species. It is not found in the shallow water of the West Indies but in deeper water only, together with *A. gibbosa* which occurs in both shallow and deeper water".

From Indian region, Chapman (1895) recorded *A. radiata* from near Laccadive island in the Arabian Sea. It was recorded by Rocha and Ubaldo (1964a) from Gogola beach and Rao and Rao (1979) from the nearshore water off Trivandrum, west coast of India. Rao *et al.* (1979) obtained it from shelf off Vishakhapatnam and Reddy and Rao (1980) from Pennar estuary Andhra Pradesh, east coast of India.

Repository of type material: AMUGD cat. No. MF 285.

4.3.21 Family CIBICIDIDAE Cushman, 1927.

Subfamily PLANULININAE Bermudez, 1952.

Genus HYALINEA Hofker, 1951.

Hyalinea balthica (Schroter)

Plate 7, figure 6.

Nautilus balthicus SCHROTER, 1783, p. 20, pl. 1, figs. 2a-b.

Hyalinea balthica (Schroter) LE ROY, 1964, p. F-44, pl. 9, figs. 34-36;- ZOBEL, 1973, p. 15, pl. 2, figs. 32-34.- SETTY, 1974, p. 23, pl. 1, figs. 6-7.

Dimensions (in mm): Length 0.6 to 0.7, width 0.5 to 0.6, thickness 0.25 to 0.28.

Remarks: *H. balthica* is considered as an indicator of cool water but Akers (in Bock, 1971) found its abundant occurrence in the warm waters of the Gulf of Mexico.

From Indian waters, *H. balthica* was reported by Zobel (1973) and Setty (1974) from the shelf sediments of Kerala, east coast, at 908 and 89 m depth respectively.

Repository of type material: AMUGD cat. No. MF 286.

Subfamily CIBICIDINAE DeMortford, 1927.

Genus CIBICIDES DeMontfort, 1808.

Cibicides lobatulus (Walker and Jacob)
Plate 7, figure 10.

Nautilus lobatulus WALKER and JACOB, 1798, p. 642, pl. 14, fig. 36 (fide, GRAHAM and MILITANTE 1959).

Cibicides lobatulus CUSHMAN, 1946, p. 9, pl. 2, figs. 6-7.- GANAPATI and SATYAVATI, 1958, pl. 6, figs. 164-166.- BHATIA, 1956, p. 24, pl. 5, fig. 7.- ROCHA and URALDO, 1964a, p. 415, pl. 3, fig. 1; 1964b, p. 647, pl. 1, figs. 1-2.- ANTONY, 1968, pp. 114-115, pl. 8, figs. 11a-b.- RAO; 1971a, pp. 14-15, fig. 82.- 1971b, p. 162.- RAO, VEDANTAM and RAO, 1979, p. 357.- REDDY and RAO, 1980, p. 170, pl. 6, figs. 12-14.

Dimensions (in mm): Length 0.40 to 0.51, width 0.35 to 0.40, thickness 0.15 to 0.17.

Remarks: C. lobatulus is a cosmopolitan species and commonly occurs in shallow marine waters. It has been reported by Norton (1930) from Florida at 15 to 922 m depth and 7.61°C to 24.7°C temperature range and from Andros Island at 1526 m in 4.0°C temperature; by Cushman (1944) as very common species from shallow water off new England coast at 6 to 13 m depth range; by Said (1949) at 30 to 1128 m depth zone in Gulf of Suez and Red sea. Todd and Bronnimann (1957) found it in nearshore zone (0 to 4 m depth) of Gulf of Paria in sublittoral and shallow deltaic areas having mostly sandy and silty substrate. Uchio (1962) found its rare specimens in sand of Wakaura, Shiraki, Nishinio and Khusimoto beaches along the Wakayama-Ken, Japan.

Haman (1966) encountered C. lobatulus from Faeroe Island, Denmark, and noted it dominant occurrence in shore sands. Atkinson (1969) found it in the littoral zones and particularly in the sub-littoral zone. In a subsequent publication, he (Atkinson, 1971) showed that the living specimens of C. lobatulus occur in littoral zone down to 13 m, all in gravel substrate, while dead tests were recorded from all the depth. Matoba (1970) observed that it is a common species in outer bay facies and are in the middle and inner bay facies. Haman (1971) found living specimens of C. lobatuluc in all the different environments of Tremador Bay, North Wales, U. K. The pH in this bay varies from 8.0 to 8.5. Sen Gupta and Schafer (1973) recorded living specimens of C. lobatulus in Chock Bay at 13 to 24 m depth in sandy and gravelly sand with mean 25.8°C temperature 35.8 ‰ salinity and 8.2 pH. Lankford and Phleger (1973) obtained this species at 11 to 40 m depth in sandy and rocky bottom substrate from near shore zone, west north America. Hopper (1975) reported a rich assemblage of C. lobatulus (43.6%) in lower St. Lawrence estuary at 0 to 80 m depth and 21 to 32 ‰ salinity ranges. Recently, Haake (1977) reported it from Adriatic Sea at a depth of 50 m. It was reported by Sen Gupta and Hays (1979) in 50-80 m depth range from the Grand Bank. Murray (1979) obtained it from 75 to 115 m depth range from Celtic sea and Corlis (1979) recorded it as a rare species from South East Indian Ocean at 2500 to 3800 m depth range. Recently, Poag et al. (1980) found it from the outer continental shelf, off New Jersey, where quartzose sand blankets the entire area and salinity ranges from 33.60 to 33.70 ‰ and dissolved oxygen varies from 7.1 to 7.5 ppm.

From Indian waters, Ganapati and Satyavati (1958) and Rao et al. (1979) recorded C. lobatulus from outer shelf region off Vishakhapatnam and Reddy and Rao (1980) from Pennar estuary, Andhra Pradesh, east coast of India, while from the west coast, Bhatia (1956) recorded it from Bhogat beach; Rocha and Ubaldo

(1964a,b) from Diu, Gogola, Simbor and Baga beaches; Antony (1968) reported it from Kerala coast at 5 to 100 m depth range; and Rao (1971) obtained it at a depth of 25.6 m with sandy mud substrate from the Gulf of Cambay. Nyholm (1961) studied in detail the morphology and biology of C. lobatulus in laboratory culture.

Summary of ecological data: Depth upto 3800 m, temperature 4 to 25.8°C, salinity 21 to 33.7 ‰.

Repository of type material: AMUGD cat. No. MF 287.

<u>Cibicides</u> <u>refulgens</u> Montfort

Plate 7, figure 11

<u>Cibicides</u> <u>refulgens</u> MONTFORT, 1808, p. 122, fig. 31c.

<u>Cibicides</u> <u>refulgens</u> CUSHMAN, 1931, p. 116, pl. 21, fig. 2.- GANAPATI and SATYAVATI, 1958, pl. 3, pl. 4, figs. 161-163.- ROCHA and UBALDO, 1964a, p. 416.- ANTONY, 1968, p. 114, pl. 8, figs. 10a-b.- RAO, 1971a, p. 14, figs. 81a-b.- ZOBEL, 1973, p. 15, pl. 1, fig. 48.

<u>Dimensions (in mm)</u>: Length 0.30 to 0.33, width 0.25 to 0.27, thickness 0.14 to 0.16.

<u>Remarks</u>: <u>C</u>. <u>refulgens</u> is a well-known and widely reported species of <u>Cibicides</u>. Norton (1930) reported it from Colding Bay, Bahamas beach, and Albatros at 922 m depth and 7.61°C temperature. Said (1949) recorded its rare occurrence from several stations (24 to 400 m depth) from the Red Sea. Uchio (1962) found it from Kuhsimoto, Seto, Nishihiro, Shiraki beaches and Mori harbour region (0 to 4 m depth) along the coast of Wakayama-Ken, Japan. Atkinson (1971) recorded living specimens of this species at 20 m depth on a gravel substrate and rarely distributed empty tests at all the depths from turbulent zone,

Cardigan Bay. Haman (1971) obtained it as widely distributed species in all the environments of Tremadoc Bay, North Wales, at 32.2 to 34.3 ‰ salinity, (Central depression) 16 to 33.1 ‰ salinity (shoal area), and 8.0 to 8.5 pH in the bay.

From the east coast of India, Ganapati and Satyavati (1958) described C. refulgens from Vishakhapatnam coast at 73 to 190 m depth and 13.33 to 25.33°C temperature ranges, while from the west coast, it was reported by Rocha and Ubaldo (1964a) from Diu, Gogola and Simbor beaches; Antony (1968) from Kerala coast in 40 to 82 m depth; Rao (1971a) at 27.4 m depth with muddy substrate from Gulf of Cambay; and Zobel (1973) from some stations of Arabian Sea.

Summary of ecological data: Depth upto 400 m, temperature 7.31 to 25.5°C, salinity 16 to 34.3 ‰.

Repository of type material: AMUGD cat. No. MF 288.

Cibicides tenellus (Reuss)

Plate 7, figure 12

Truncatulina tenella REUSS, 1865, p. 477, pl. 5, fig. 6.

Cibicides tenellus (Reuss) TEN DAM and REINHOLD, 1942, p. 99, pl. 8, fig. 6, pl. 10, fig. 2.

Dimensions (in mm): Length 0.4 to 0.6, width 0.33 to 0.34, thickness 0.16 to 0.17.

Remarks: This is the first record of C. tenellus from modern seas. C. tenellus was originally described from Upper Oligocene of Doberg near Bunde, Germany. Kaasschieter (1961) recorded it from Eocene of Belgium and our specimens having an average of 11 chambers in last whorl and biconvex test, are similar to those figured and described by Kaasschieter (op. cit.)

Repository of type material: AMUGD cat. No. MF 289.

Cibicides sp. indet.

Plate 7, figure 14

Dimensions (in mm): Length 0.30, width 0.27, thickness 0.18.

Remarks: A few abraded specimens of Cibicides were found in our material which could not be referred to any known species of the genus. Our specimens have dense pores on both sides and the regular growth of chambers result in almost a rounded test. Some more specimens are needed for assigning it to some known species of Cibicides.

Repository of type material: AMUGD cat. No. MF 290.

Genus CARIBEANELLA Bermudez, 1952.

Caribeanella indica n. sp.

Plate 7, figure 15.

Caribeanella sp. BHATIA and KUMAR, 1976, p. 243, pl. 2, fig. 11.

Descriptions: Test of medium size, trochospiral, rounded, biconvex, ventral side more convex, dorsal side evolute, chambers 21; sutures distinct, simple gently curved, flush in early portion but slightly depressed in later portion; ventral side involute, chambers 10, sutures simple, curved, flush, umblical plug medium, raised; periphery rounded, slightly lobulate in later part, acute; primary aperture a low arch on base of apertural face, with lip; smaller secondary apertures with lip at basal backward margin of each chamber on periphery, arch-shaped, faintly visible, supplimentary apertures on spiral suture, wall calcarcous, radial, perforate; last chambers more coarsely perforate.

Dimensions (in mm):	Holotype	Other specimens
Maximum length	0.58	0.55 to 0.61
Minimum length	0.43	0.29 to 0.32
Thickness	0.16	0.15 to 0.17

Illustrations Plate 7, figures 15a–c.

Variations: The present new species of Caribeanella shows a little variation in the shape and size of the test. Dorsal side varies from plano-convex to convex and chambers vary from 19 to 23.

Remarks: This distinctive new species of Caribeanella does not resemble to any known species of the genus. Bhatia and Kumar (1976) recorded a species of Caribeanella-caribeanella sp.- from shallow water, near Anjidiv Island, Karwar, west coast of India, but kept it under open nomenclature. Caribenella indica shows close resemblance to Caribeenella sp. described by Bhatia and Kumar (op. cit.) and both are identical. Hence, Caribeanella sp. is being included here within the scope of C. indica sp. nov.

Type Horizon: Recent beach sand.

Type locality: Juhu beach sands. Also found in Arambol, Ratnagiri and Calangute beaches along the west coast of India.

Geological age: Recent.

Repository of type material: AMUGD cat. No. MF 291.

Etymology: The present new species derives its name from India where it has been found for the first time.

Superfamily CASSIDULINACEA D'orbigny, 1839.

4.3.22 family CAUSASINIDAE, Bykova, 1959.

Subfamily FURSENKONIA Loeblich and Tappan, 1961.

Genus FURSENKONIA Loeblich and Tappan, 1961.

Fursenkonia pontoni (Cushman)

Plate 7, figure 5.

Virgulina pontoni CUSHMAN, 1932, p. 17, pl. 3, fig. 7.

Fursenkonia pontoni (Cushman), SETTY, 1976, p. 229.- NIGAM, SETTY and AMBRE, 1980, p. 249.

Dimensions (in mm): Length 0.43, width 0.12.

Remarks: F. pontoni is a widely reported species. Parker (1954) observed that its frequency may be as high as 4% at stations less than 105 m deep from north-eastern Gulf of Mexico. Lankford (1959) recorded it from east Mississippi delta region as an open shelf fauna, at 119 m depth, 36‰ salinity, 17 to 31°C (surface) and 16 to 22°C (bottom) temperature ranges. Phleger (1964) found its living specimens from shelf of California and noted its maximum concentration in 36 to 72 m depth range. Sen Gupta and Schafer (1973) recovered living specimens of F. Pontoni (=Virgulina pontani) from Castries Bay in 4 to 17 m depth and observed that the species preferred muddy substrate, with 25.8°C mean temperature, 35.8 ‰ salinity, and 8.2 pH.

Seiglie (1974) found F. pontani as a best indicator of pollution and observed unusual increase in the percentage of living Fursenkonia population as compared to the dead one in the Mayagues Bay, off the central west coast of Puerto Rico. Scott et al. (1976) found living specimens of F. pontani from San Diego Bay at 3 to 12 m depth and 31 to 33 ‰ salinity ranges.

From Indian waters, Setty (1976) recorded F. pontani from polluted marine environment of Cola Bay, Goa, west coast of India. Recently, Nigam et al. (1979) encountered it from shelf region off Ratnagiri within 15 to 50 m depth range though it was rare in frequency.

Summary of ecological data: Depth upto 119 m, temperature 17 to 31°C (surface), 16 to 22°C (bottom) salinity 35.8 to 36.0 ‰.

Repository of type material: AMUGD cat. No. MF 292.

4.3.23 Family NONIONIDAE Schultze, 1854.

Subfamily NONIONINAE Schutze, 1854.

Genus <u>NONION</u> De Montford, 1808.

<u>Nonion</u> <u>boueanum</u> (D'orbigny)

Plate 6, figure 16.

<u>Nonionina</u> <u>boueana</u> D'ORBIGNY, 1846, p. 108, pl. 5, figs. 11-12.

<u>Nonion</u> <u>boueanum</u> (D'orbigny).- CUSHMAN, 1939, pp. 12-13, pl. 3, figs. 7-8.- SETHULEKSHMI AMMA, 1958, p. 21, pl. 1, fig. 32.- ROCHA and UBALDO, 1964b, p. 647, pl. 1, fig. 16.- ANTONY, 1968, pp. 57-58, pl. 3, fig. 25.- RAO, 1970b, p. 262, fig. 42.

<u>Dimensions (in mm)</u>: Length 0.43 to 0.50, width 0.36 to 0.40, thickness 0.16 to 0.19.

<u>Remarks</u>: The types of <u>N.</u> <u>boueanum</u> are from the Miocene of Nussdrof, Vienna Basin. It has been recorded from different parts of the world, including North and South Pacific, Red Sea, South Italy, Hongkong, Belgium and Arabian Ses.

From the Indian region, <u>N.</u> <u>boueanum</u> is known only from the west coast. Sethulekshmi Amma (1958) reported it from Travancore coast; Rocha and Ubaldo (1964b) from Baga beach; Antony (1968) from Kerala coast at 25 to 1000 m depth range; and Rao (1970b) from the Gulf of Cambay.

Repository of type material: AMUGD cat. No. MF 293.

Nonion sp.

Plate 6, figure 14.

Dimensions (in mm): Length 0.33, width 0.30, thickness 0.14.

Remarks: Only a few specimens of genus Nonion having almost rounded test, carinate pheriphery, and depressed sutures were recorded in our material which do not resemble any known species of the genus. Specific identification needs some more, better preserved, specimens.

Repository of type material: AMUGD cat. No. MF 294.

Genus FLORILUS De Montfort, 1808.

Florilus elongatus (D'orbigny)

Plate 6, figure 15.

Nonionina elongata D'ORBIGNY, 1826, p. 1294, no. 20.

Florilus elongatum BELFORD, 1966, p. 158, pl. 31, figs. 8-12.

Dimensions (in mm): Major diameter 0.40 to 0.46, minor diameter 0.31 to 0.40, thickness 0.15 to 0.17.

Remarks: Nonion elongatum (D'orbigny) as described and illustrated by Cushman (1939) shows broad and low, rapidly enlarging chambers with flaring test and, on this basis, was transferred to genus Florilus by Belford (1966).

Dev (1975) made a case study of three closely allied species, viz., N. boueanum, Florilus elongatus and F. scaphum and his views regarding the distinction between these three species have been followed in the present study.

Repository of type material: AMUGD cat. No. MF 295.

Florilus scaphus (Fichtel and Moll)

Plate 6, figure 13

Nautilus scapha FICHTEL and MOLL, 1798, p. 105, pl. 19, figs. a-f.

Nonion schapha (Fichtel and Moll) CUSHMAN, 1937, p. 20, pl. 5, figs. 18-21.- BHATIA, 1956, p. 19, pl. 5, fig. 15.- ROCHA and UBALDO, 1964a, p. 10, pl. 3, figs. 4a-b; 1964b, p. 647, pl. 1, fig. 17.- RAO, 1971b, p. 159, fig. 34.

Nonion scaphum (Fichtel and Moll) CUSHMAN, 1930 (1918, etc). p. 5, pl. 2, figs. 3-4, pp. 11-14, pl. 3, figs. 7-10.- BHATIA and BHALLA, 1964, p. 79, pl. 1, figs. 6a-b.- ANTONY, 1968, pp. 58-59, pl. 4, fig. 1.

Florilus scaphum (Fichtel and Moll), BHALLA, 1970, p. 160, pl. 21, figs. 5a-b.- BHATIA and KUMAR, 1976, p. 242.- RAO, VEDANTAM and RAO, 1979, p. 361.

Dimensions (in mm): Major diameter 0.28 to 0.40, minor diameter 0.21 to 0.30, thickness 0.13 to 0.15.

Remarks: A review of literature shows that *F. scaphus* exhibits a fairly wide range of variation and its variants have been described by various authors under different names. Bhalla (1970) transferred this species from *Nonion* to *Florilus* due to broad and low chambers and flaring nature of the test.

F. scaphus has been reported from west and east coasts of India. Bhatia and Bhalla (1964) described it from Puri beach; Bhalla (1970) from Marina beach sands, Madras; and Rao et al. (1979) encountered rare occurrence of this species in 20 to 90 m depth range from shelf region off Vishakhapatnam on the east coast of India. From the west coast, this species has been reported by various authors, including Bhatia and Kumar (1976) who recorded it from Anjidiv Island, near Karwar, in 5 to 13 m depth, 28.7 to 30.1°C temperature and 33.49 to 34.01 ‰ salinity ranges.

Repository of type material: AMUGD cat. No. MF 296.

4.3.24 Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus HANZAWAIA Asano, 1944

Hanzawaia concentrica (Cushman)
Plate 7, figure 13

Truncatulina concentrica CUSHMAN, 1918, p. 64, pl. 21, fig. 3.

Hanzawaia concentrica (Cushman), TODD and LOW, 1961, pp. 17-18.- ZOBEL, 1973, pl. 1, figs. 44-45.- RAO, VEDANTAM and RAO, 1979, p. 356.

Dimensions (in mm): Length 0.22 to 0.25, width 0.17 to 0.19, thickness 0.09 to 0.10.

Remarks: Cushman (1944) recorded abundant specimens of H. concentrica from 11 to 24 m depth in Vineyard Sound and less common in Buzzard Bay at 15 m depth. Todd and Low (1961) reported it in fine sand from open sea beaches, south-east of Gay Head in 19 to 23°C temperature and 31.1 to 32.1 ‰ salinity ranges. Seiglie (1974) found living specimens of H. concentrica in polluted marine environment of Mayagüez Bay in 24 to 29°C temperature and 33.3 to 36.8 ‰ salinity ranges. Adegoke et al. (1977, vide Sen Gupta, 1977) noted its abundant occurrence in upper shelf (10 to 40 m depth) and rare occurrence in nearshore turbulent and middle shelf (40 to 120 m depth) zones from Nigerian continental shelf. Sen Gupta (1977) made a cluster analysis of modern benthic foraminifera from continental shelves and recognised H. concentrica as common member of thanatope around the shelf edge (about 50 m depth). Recently, Poag et al. (1980) recorded it in 33.6 to 33.7 ‰ salinity and 7.1 to 7.5 ppm dissolved oxygen range from outer continental shelf, off New Jersey, where quartzose sand blankets the entire area.

From Indian waters, Zobel (1973) encountered H. concentrica in 53 to 110 m depth from the Arabian Sea near Karachi, Bombay and Karwar, whereas Nigam et al. (1979) found it in 15 to 50 m depth, off Ratnagiri, west coast. From the east coast, Rao et al. (1979) recorded this species from shelf region, off Vishakhapatnam in 30 to 190 m depth range.

Summary of ecological data: Depth 0 to 190 m, temperature 19 to 29°C and salinity 31.1 to 36.8 ‰.

Repository of type material: AMUGD cat. No. MF 297

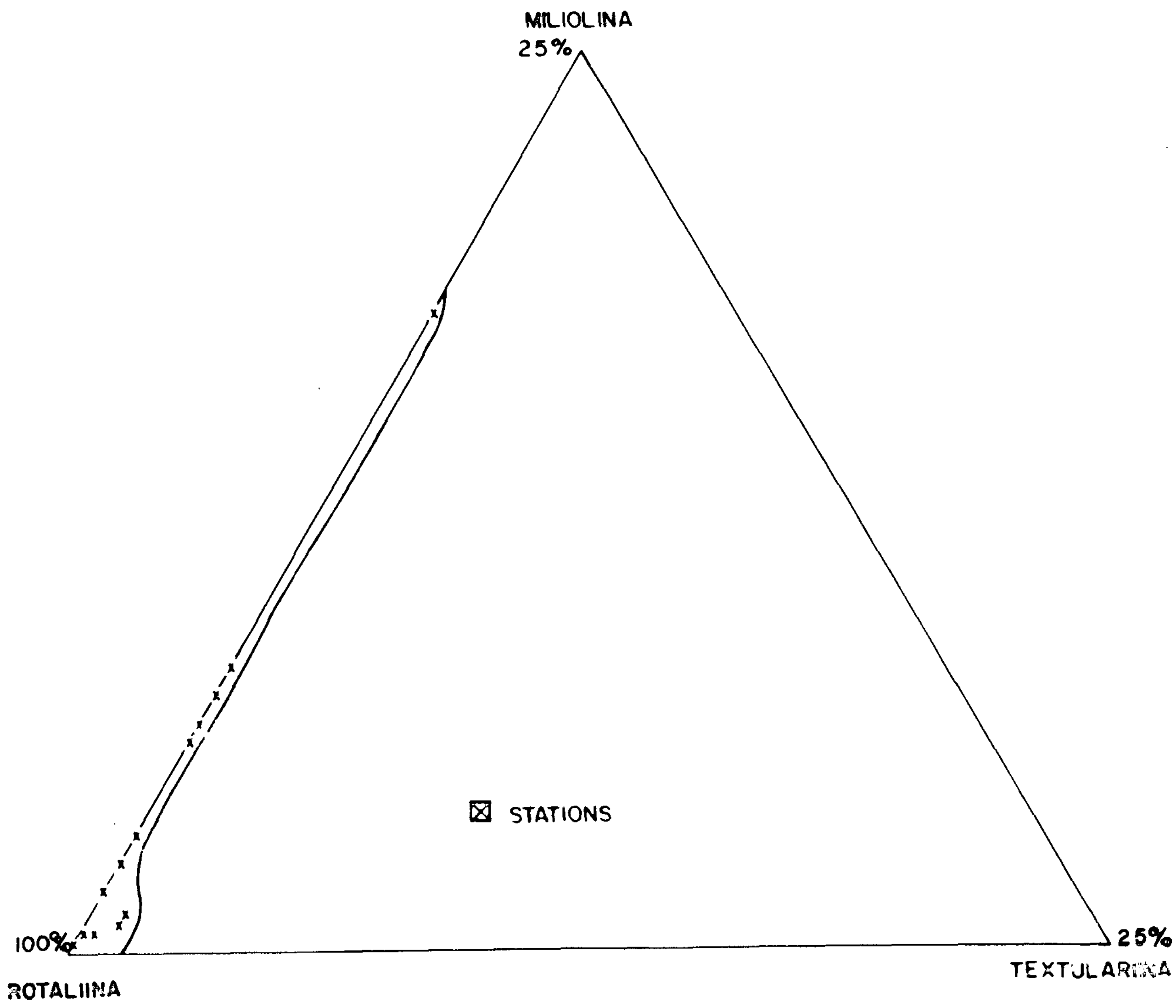


FIG._10 SHOWING DISTRIBUTION OF TOTAL FORAMINIFERAL NUMBER BELONGING TO ROTALIINA, MILIOLINA AND TEXTULARIINA ALONG WEST COAST OF INDIA.

CHAPTER 5

COMPOSITION OF FORAMINIFERA

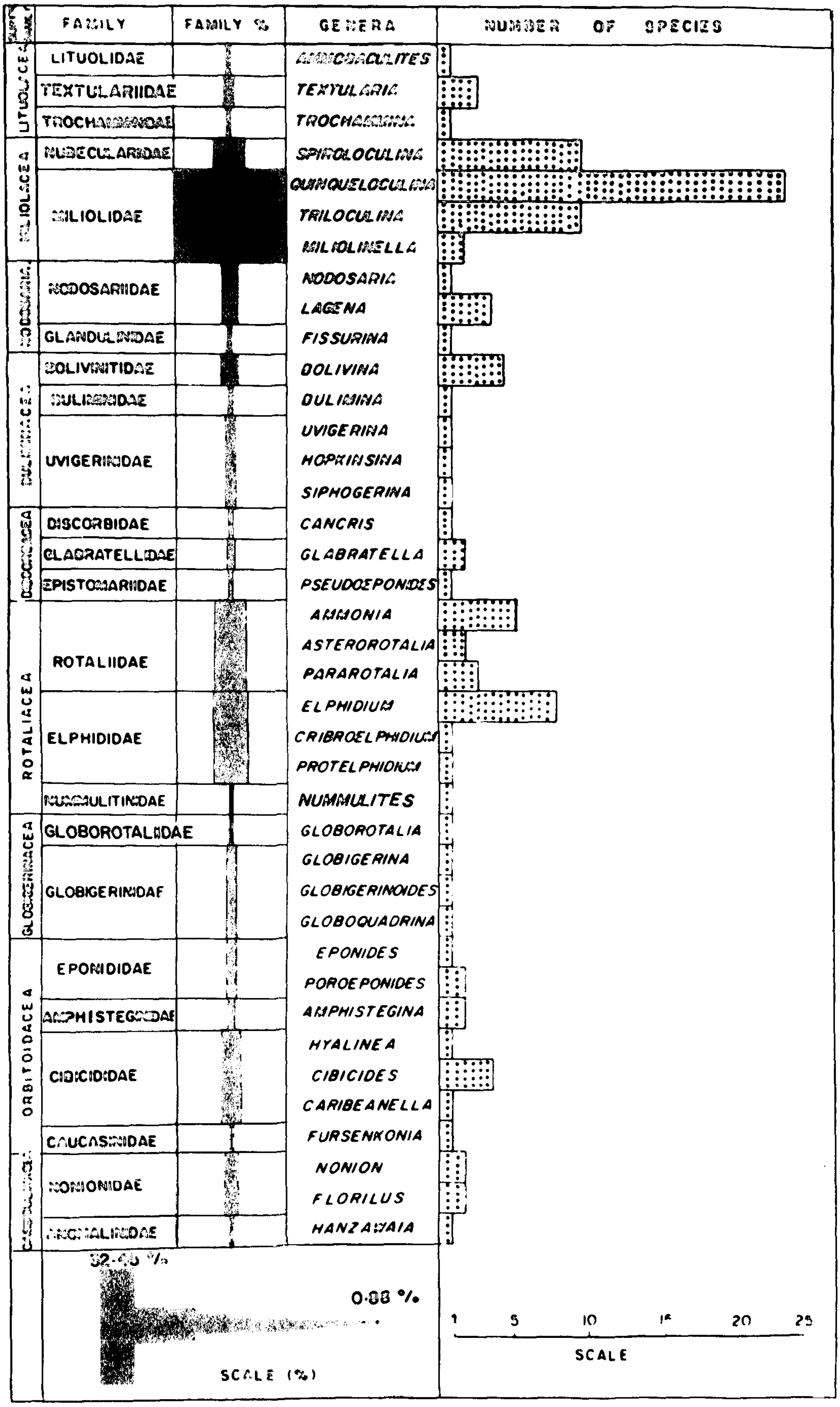
A representative material (5 g) was taken from each beach which shows a rich assemblage of foraminifera. Compositional study is divided into two parts: composition of foraminifera with reference to total foraminiferal number (TFN) and, total species number (TSN).

5.1 TOTAL FORAMINIFERAL NUMBER (TFN).

Since it was very difficult to identify all the broken specimens up-to species level, total percentages were calculated up-to generic and family levels.

The study shows that the fauna is mostly composed of Rotaliina (82.25 to 99.72%). Textulariina never exceeds 0.83 % of the total population and Miliolina is also rare (0.28 to 17.75 %) in occurrence.

Within the suborder Rotaliina, family Rotaliidae (Ammonia + Pararotalia + Asterorotalia) is most abundant and constitutes 45 to 99% of the total population.



FIG_II COMPOSITION OF TOTAL FORAMINIFERAL SPECIES, WEST COAST, INDIA.

Following the method described by Murray (1973), a triangular model for displaying the percentage of three main suborders, viz., Textulariina, Miliolina and Rotaliina was prepared (Fig. 10). Murray's (1973) model has been found useful for environmental studies, particularly to establish a standard model for paleo-ecological interpretations. It is hoped that the present work will serve as a model for beach fauna in future studies, at least of this part of the world.

5.2 TOTAL SPECIES NUMBER (TSN)

The foraminiferal assemblage comprises 114 species belonging to 9 super-families, 24 families and 39 genera. Of these, Miliolidae is the most dominant family and is represented by 37 species (32.45%). The next abundant family is Elphididae, represented by 11 species (9.65% each); followed by Nubeuclariidae and Rotaliidae each having 10 species (8.77%). Of the remaining, 6 species belong to Cibicidae (5.26%); 5 (4.39%) each to Nodosariidae and Bolovinidae; 4 species (3.51%) to Nonionidae; 3 (2.63%) each to Textulariidae, Uvigerinidae, Globigerinidae, Eponididae; 2 (1.75%) each to Glabratellidae and Amphisteginidae; and 1 (0.88%) each to Lituloliidae, Trochamminidae, Glandulinidae, Buliminidae, Discorbidae, Epistomariidae, Nummulitidae, Globorotaliidae, Caucasinidae and Anomalinidae (fig. 11). Distribution of species are presented in Table 6. Four species are new, namely, Quinqueloculina haqni, Q. singhi, Triloculina qasimi and Caribcanella indica which have been described in detail.

Below is the list of species which are being reported for the first time from the Indian waters: Spiroloculina rotunda, S. tricarinata, Quinqueloculina bicarinata, Q. mediterranensis, Q. oblonga, Q. phoenica, Q. polygona, Q. rugosa, Q. aff. Q. viennensis, Miliolinella australis, M. oblonga, Lagena vulgaris, Bolivina laevigata, Ammonia indica, Cribroelphidium sp., Pararotalia minuta and Cibicides tenellus.

5.3 DISCUSSION

5.3.1 Relationship between TSN and TFN

As noted earlier, total foraminiferal number and total foraminiferal species are related to latitudinal variation. The inter-relationship between TSN and TFN has also been worked out in the present study. Correlation coefficient and linear regression equation were computed on TDC 316 computer and relationship between TSN and TFN was found as follows:

$$Y = 279.6 - 6894.51\,x$$

$$r = 0.769$$

The value of r shows significantly positive relationship between TSN and TFN as it is higher than 0.1 level of significance, which is equal to 0.47 (Fisher and Yates, 1963).

5.3.2 Planktonic foraminifera

The foraminiferal assemblage of the beach fauna from the west coast comprise almost entirely of benthonic species. The planktonic foraminifera are rare and only few specimens were encountered belonging to 4 species, viz., Globorotalia cultrata cultrata, Globigerina bulloides, Globigerinoides ruber and Globoquadrina dutertrei. The ratio of planktonic/ benthonic species is 1 : 28.75.

Planktonic foraminifera generally thrive in offshore regions, but the sporadic occurrence of some specimens in the present assemblage is, perhaps due to tidal waves and/or occasional sea-storms.

TABLE 6: Distribution of foraminiferal species from sandy beaches of western India.

Foraminifers	Beaches (1 to 13) Fig.1 Juhu	Ratnagiri	Arambol	Chapora	Anjuna	Calangute	Condolim	Karwar	Mangalore	Calicut	Quilon	Sangomukum	Kanniyakumari
	1	2	3	4	5	6	7	8	9	10	11	12	13
***Ammobaculites persicus* Lutze**	F			R				F	R	F			
Textularia agglutinans D'orbigny		R											
T. conica D'orbigny		R	R										
T. foliacea Heron-Allen and Earland		R	R										
Trochammina hadai Uchio								R					
Spiroloculina aequa Cushman	R	R				R							R
S. antillarium D'orbigny		R	R		R	R		R					
S. communis Cushman and Todd	R	R	R					A					

	1	2	3	4	5	6	7	8	9	10	11	12	13
S. excavata D'orbigny						R		R	R	R			
S. eximia Cushman	F	F	A	R	R	R	R	F	R				
S. indica Cushman and Todd			R					F		R			
S. planissima Wiesner	R	A	R	R	R	R		F	F				
S. rotunda D'orbigny		R			R	R		R	R				
S. scita Cushman and Todd		F											
S. tricarinata Terquem		A		R	R	R	R	R	R				
Quinqueloculina agglutinata Cushman							R						
Q. cf. Q. bicaraninata D'orbigny	R	R			R	R			R				
Q. bicornis (Walker and Jacob)	R												R
Q. hagni n. sp.		F											
Q. kerimbatica (Heron-Allen and Earland)	R	R	R			F							
Q. laevigata D'orbigny	A		R										R
Q. lamarkiana D'orbigny	R	R				R							
Q. ludwigi Reuss	R	R	R		R	R			F	R			
Q. mediterranensis Le Calvez		R											

	1	2	3	4	5	6	7	8	9	10	11	12	13
Q. oblonga (Montagu)	R	R	R	R	R	R	R	R	R				R
Q. parkeri (Brady)	R	R	R			R				R			
Q. phoenica Colom	R								R				
Q. polygona D'orbigny	R			R									R
Q. pseudoreticulata Parr	R	R	F		A	R							
Q. rugosa D'orbigny	R		R										
Q. schlumbergeri (Wiesner)	R	F						R					
Q. seminulum (Linne)	A	A	A	R	A	F	R	R	R				
Q. singhi n. sp.		R		R	R	R							
Q. undulosa costata Terquem	R	R	R			R							
Q. venusta karrer	R	R	R		R	R	R						
Q. aff. viennensis Le Calve	R	R	R		R	R							
Q. vulgaris D'orbigny	A	A	A	A	A	R	R	R	R	R	R		F
Q. tropicalis Cushman				R									
Q. sp. A	A	R	R				R	R					
Q. sp. B			R		R			R					

	1	2	3	4	5	6	7	8	9	10	11	12	13
Triloculina insignis (Brady)	R	R						R					
T. aff. *T. echinata* D'orbigny	R										R		R
T. laevigata D'orbigny	R												
T. oblonga (Montagu)	R												
T. gasimi n. sp.	R							R					
T. rotunda D'orbigny	R							R					
T. rupertiana (Brady)		R			R								
T. terquemiana (Brady)		R	R		R	R							
T. tricarinata D'orbigny	R	R	R	R		R		R	R	F	R		R
T. trigonula (Lamark)			R							R			R
Miliolinella australis (Parr)	F					R		R					R
M. oblonga (Montagu)	F							R					
Nodosaria sp.	R												
Lagena laevis (Montagu)	R												
L. perlucida (Montagu)	R												
L. semistriata Williamson	R												

	1	2	3	4	5	6	7	8	9	10	11	12	13
L. vulgaria Williamson	R												
Fissurina laevigata Reuss	R												
Bolivina laevigata (Williamson)	R												
Bolivina limbata (Brady)	A												
B. persiensis Lutze	A												
B. striatula Cushman	R												
B. cf. B. variablis (Williamson)	A												
Bulimina marginata D'orbigny	F												
Uvigerina auberina D'orbigny	F												
Hopkinsina glabra (Millet)	F												
Siphogenerina rephanus (Parker and Jones)	A	R											R
Caneris auricula (Fichtel and Moll)	R							R					
Glabratella patelliformis (Brady)	R												
G. Sp.			R							R			
Pseudoeponides nakazotoensis (Kuwano)	R	R				F		R					

	1	2	3	4	5	6	7	8	9	10	11	12	13
Ammonia annectens (Parker and Jones)	A	A	R	R	R	A	A	A	A	F	A	R	R
A. indica (Le Roy)	R	R						R	R				
A. papillosus (Brady)	A	A	F	R	R	R		A	F	F	R	R	A
A. sobrina (Shupack)	A	A	A	R	R	R	R	A	F	R			R
A. tepida (Cushman)	F	R	F	A	R	R		A	R	R			
Asterorotalia dentata (Parker and Jones)		F	R	R				A	F	F			
A. inflata (Millet)	A		F			F						R	
Pararotalia calcar (D'orbigny)			F	R									
P. minuta (Takayanagi)	A	A	A	R					R	R			R
P. nipponica (Asano)	A	A	A	A	A	A	F	R	R	R	R	R	R
Elphidium advenum (Cushman)	A	A	A	A	F	R	R	R			R		R
E. craticulatum (Fichtel and Moll)		R	R			R					R	R	R
E. crispum (Linne)		F	R		R	R			R	R	F	R	R
E. discoidale mutiloculatum Cushman & Ellisore	R	R	R			R		F	R	R			R
E. indicum Cushman	R	A			R	F	R		R				

	1	2	3	4	5	6	7	8	9	10	11	12	13
E. macellum (Fichtel and Moll)											R	R	
E. minutum (Reuss)	A			R		R	R		R	R			
E. simplex Cushman	R	R		R		R		R		R			
E. sp.	F												
Cribroelphidium sp.								R					
Protelphidium aff. P. granosum (D'orbigny)	R												
Nummulites ammonoides (Gronivius)	R	R	R			R							
Globorotalia cultrata cultrata (D'orbigny)								R					
Globigerina bulloides D'orbigny	R	R	R	R		R		R	R	R			
Globigerinoides ruber (D'orbigny)				R		R		R	R				
Globoquadrina dutertri (D'orbigny)								R					
Eponides repandus (Fichtel and Moll)	A	A	R	R	R	A	R		F	R	R		R
Proeponides cribrorepandum (Asano and Uchio)	A	A	A	R	A	A	R		R	R	R	R	F
P. lateralis (Terquem)	R	R	R	R	R	R							R

	1	2	3	4	5	6	7	6	9	10	11	12	13
Amphistegina medagascariensis D'orbigny												R	A
A. radiata (Fichtel and Moll)						R			R		R	R	A
Hyalinea balthica (Schroter)												R	
Cibicides lobatulus (Walker and Jacob)	R	R	F			R					R		
C. refulgens Montfort	A	A	R		R	R							
C. tenellus (Reuss)	R	R	R		R	R							
C. sp.	R												
Caribeanella indica.n. Sp.	R	R	R			R							
Fursenkonia bontoni (Cushman)	R			R									
Nonion boueanum (D'orbigny)	A	A	A		R	R	R	A	R	R	R		R
N. Sp.		R	R										
Florilus elongatus (D'orbigny)	A	F	A	A		R	R	A	R	R			R
F. scaphus (Fichtel and Moll)	A		R	R	R	R	R	A	R	R	R		F
Hanzawaia concentrica (Cushman)	A												

R- 1-5 specimens, F- 5-15 specimens, A 715 specimens

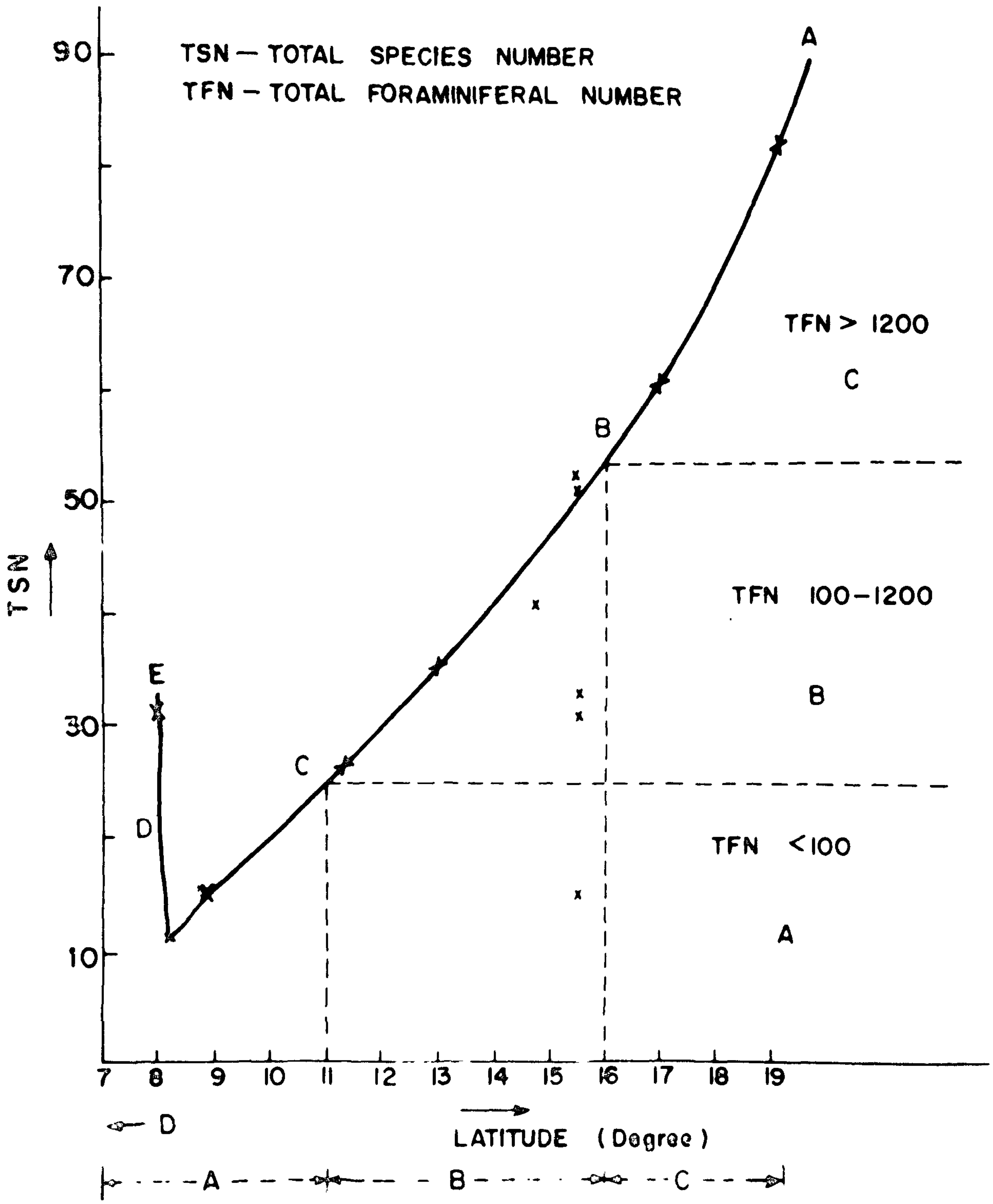


FIG._12 LATITUDINAL VARIATION IN TOTAL FORAMINIFERAL SPECIES, WEST COAST, INDIA.

CHAPTER 6

LATITUDINAL VARIATION

Certain parameters like temperature and salinity sometimes vary with latitudes and this variation is reflected in the foraminiferal assemblage. Recently, Frerichs et al. (1972) showed latitudinal variation in the planktonic foraminiferal test porosity.

In the present study an attempt has been made to work out the variation of foraminiferal assemblage with latitude.

6.1 LATITUDINAL VARIATION AND TFN

Total foraminiferal number (TFN) in 5 g dried material from each beach was counted and it is observed that it varies with latitude (fig. 12). On the basis of TFN west coast can be divided into 3 zones. A. from 8°N to 11°N with lowest TFN ($<$ 100); B. from 11°N to 16°N with TFN 100-1200; and C. from 16°N to 19°N with highest TFN ($>$ 1200).

6.2 LATITUDINAL VARIATION AND TSN

In the present material from the west coast, 114 species

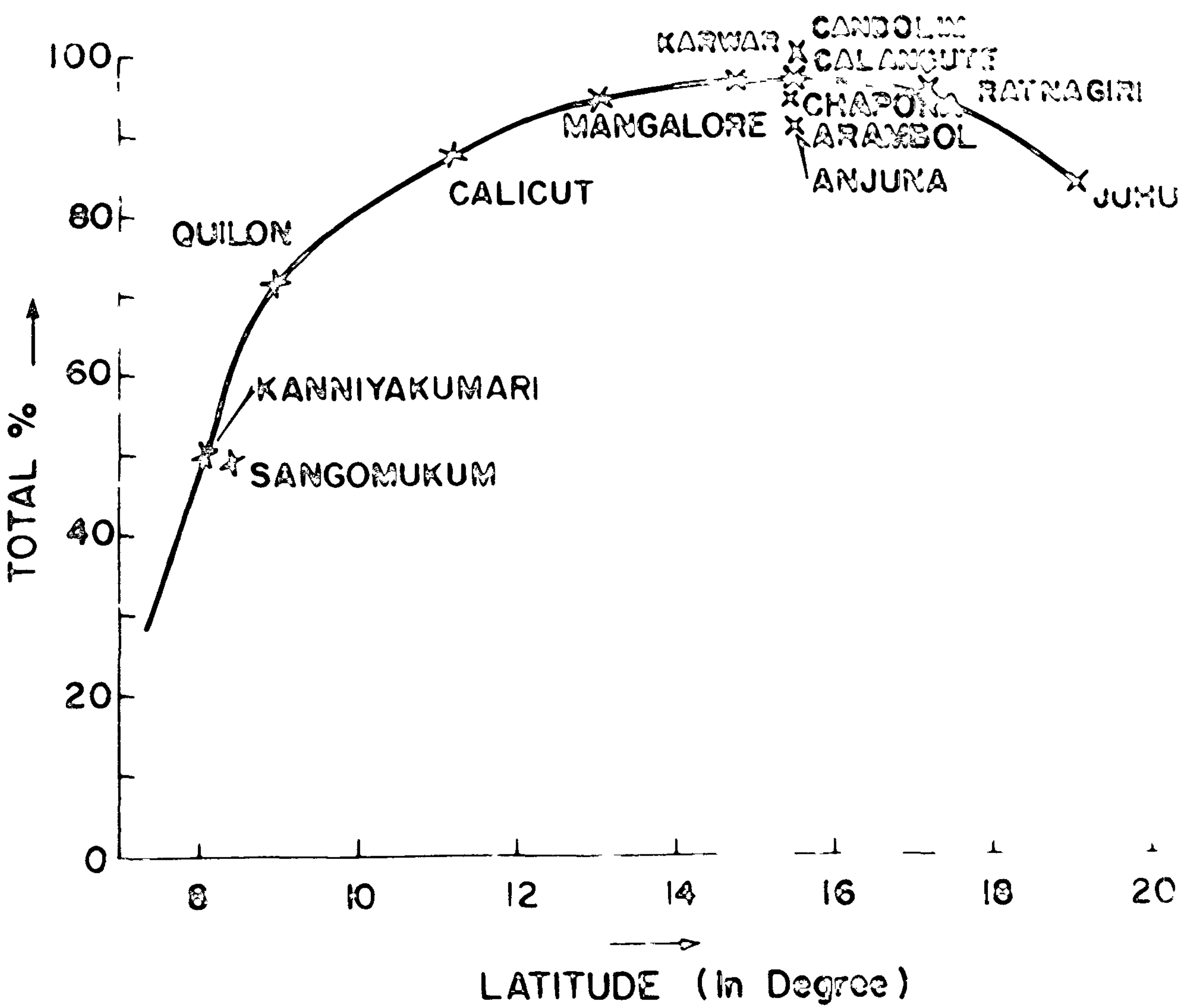


FIG._13 LATITUDINAL VARIATION IN TOTAL FORAMINIFERAL NUMBER OF ROTALIINA.

of foraminifera have been recorded. It is observed that total species number (TSN) decreases with decrease in latitude. Highest number of species (82) was recorded at Juhu in the North and lowest at Quilon and Sangomukum (15 and 11 respectively) in the south. Most of the points may be joint by a smooth curve (fig. 12).

6.2.1 Abnormal behaviour of some beaches

In the above study, 4 stations showing abnormal nature than the general trend of foraminiferal distribution were observed. Some possible explanations are given below:

(i) Kanniyakumari beach: This beach is at the junction of the East and West coast of India and species of both the coasts are present here. However, the fauna is more aligned to the west coast as discussed in the sequel.

(ii) Anjuna, Chapora and condolim beaches: All these beaches are situated in Goa. Chapora is an estuarine beach and fauna of Candolim and Anjuna beaches are highly inflcenced by rivers (fig. 1). This is, perhaps, the reason for lower value of TSN.

6.3 LATITUDINAL VARIATION IN DISTRIBUTION OF SOME IMPORTANT GROUPS

It is clear from fig. 10 that fauna of the west coast is mostly composed of the members of Rotaliina. Textulariina never exceeds 0.83 % of total population and hence it has not been taken into consideration.

(i) Miliolina is 5% to 7% in Zone C (16°N to 16°N), 0.28% to 1.17% in Zone B (16°N to 11°N) and 3% to 7% in Zone A (11°N to 8°N). Maximum percentage of Miliolid (17.75 %) is at Anjuna beach which is an exception and might be due to its protected and rocky nature.

(ii) Rotaliina: is the most common suborder in our material. Of all the species of this suborder, those belonging to family Rotaliidae (*Ammonia* + *Pararotalia* + *Asterorotalia*) constitute 50 to 99% of the total population. Variation in the distribution of this subfamily with latitude is shown in a figure 13. The study, shows that values are lowest (49%) at Kanniya-kumari and increases very rapidly with gain in latitude. A very little down fall in the curve is noticed at Juhu beach where it is 84%.

(iii) Amphistegina shows maximum concentration at extreme south (Kanniyakumari beach). Afterwards, at decreases towards north and almost vanishes beyond Calicut beach.

(iv) Nummulites also follows the same trends as Amphistegina and is rare beyond Quilon beach in the North.

(v) Nonion is very rare (recorded only in floatation of large volume of sample in carbon-tetrachloride) in the south (Kanniyakumari and Quilon) and its maximum concentration (3.39%) was recorded at Juhu beach.

(vi) TFN value of Elphidium is 5.77% at Juhu, decreases up to Mangalore (0.39%), and from Calicut up to the southern extreme, it shows increase in values.

(vii) TFN values for Eponides (0.1 to 3%) and Cibicides (0.08 to 1.76 %) do not exhibit any marked variation with latitude.

CHAPTER 7

RELICT FORAMINIFERA

Murray (1973, p. 238) stated, "Older foraminiferids are often different in colour and lack of fresh appearanco of the recent forms. Where subrecent deposits are eroded, it may not be so easy to recognise reworked specimens." 'Murray's statement holds true in the present study also. Some broken, filled and old looking foraminiferal tests without any lusture have been recorded at certain beaches on the southern part of the west coast. The percentage ratio of these re-worked, relict, specimens to the total population is as follows:

	Beach		Ratio
1.	Quilon	..	47.60
2.	Sangomukum (Trivandrum)	..	47.62
3.	Kanniyakumari	..	74.25

Generally, foraminiferal population is very poor at all the above beaches. However, species which are present in this transported material are Amphistegina sp., Nummulites sp. (opercutina), Elphidium sp. Havlinea sp, Quinqueloquelina, and Triloulina.

No direct source is known for the occurrence of this transported material. However, their presence in the southern beaches may be explained by some indirect evidences. Nair (1974) postulated sea-level fluctuations in the Arabian sea and gave an idea of Relict sand zone (oolitic sand). The sediments of this zone have been radio-carbon dated from 9000 to 11000 years old (Nair, 1974) and a very low foraminiferal diversity has been recorded in this zone at the stations off Bombay (Hashimi et al., 1978a). Some dead coral reefs have also been recorded in dredge operation on Board R.V. Gaveshani (unpublished N.I.O. reports for cruise No. 29 and 48) at stations off Ratnagiri. This sand carpet runs continuously from North to South. In the North, this zone is covered by Recent terrigenous material brought by major rivers like Indus, Tapti and Narmada. At Bombay, distance of this zone from the shore is about 160 Km, but towards south, it comes gradually near to the shore and finally it touches the coast near Quilon. This is due to lack of any major river in the southern part of the coast and hence the supply of terrigenous material is practically negligible.

In the light of foregoing discussion, it may be postulated that the relict and/or reworked specimens of foraminifera might have been derived from the relict sand zone and deposited on the beaches due to tidal and back water action.

Another source of the derived nature of the sediments may be the Tertiary rocks which are exposed near coastal areas. Rao (1968, p. 548) studied the sediments from near-shore region of Kerala (10 to 12 m) and stated, "Associated with the emergent coast as is believed it is difficult to decide whether these surface sediments of limited thickness investigated present the transitinary sedimentation of modern time or belong to an episode of the trangressive seas at the end of Pleistocene glaciation. It is quite possible that there is a reworking of the sediments laid down in an earlier episode with simultaneous addition from the rivers".

Hence, on the basis of limited information available, it is not possible to decide the exact source of these reworked specimens. Only a detailed study dealing with coastal rocks and offshore samples collectively could give a satisfactory explanation.

CHAPTER 8

FORAMINIFERA AND POLLUTION

8.1 INTRODUCTION

When the natural balance of an environment is disturbed by the introduction of pollutent, an ecological shift in the biotic set-up takes place, resulting in a 'modified environment' known as pollution. Being very sensitive to slight change in environment, foraminifera serve as good indicators of marine pollution.

Effect of pollution on benthonic foraminiferids was studied earlier by Bandy (1964), Bandy et al. (1964), Harman (1964), Seiglie (1968, 1971), Schafer (1970, 1973), Schafer and Kole (1974), Bates and Spencer (1979) amongst others. In the India, Setty (1976), Rao and Rao (1979), Setty and Nigam (1980) and Bhalla et al. (In press) also worked out the effects of pollution on foraminiferids.

Of all the beaches included in the present study, polluted environment only at one beach, namely, Sangomukum was observed.

8.2 ENVIRONMENTAL SETTING

The environment at Sangomukum beach at Trivandrum is polluted due to effluent discharge by Travancore Titanium Products Limited into the Arabian sea, near to this beach. The effect of pollution was noted upto 1/2 km from the shore and surface and littoral current patterns were studied earlier (N. I. O. report No. 51, 1980).

Normal salinity of surface water at Sangomukum varies from 34.38 ‰ to 34.9 ‰ but at the site, where the mixing of effluent with the sea water occurs, it was found to be 26.64 ‰.

Temperature of normal near-shore sea water at Sangomukum was 28.8 to 29.4°C. However, it was 45.8°C in effluent, 36°C at mixing site, and 29.1°C in distal zone.

Normally, pH ranges from 7 to 7.5 but it varies from 1.4 to 2 near the discharge point at Sangomukum.

8.3 POLLUTIONAL EFFECT ON FORAMINIFERA FROM SANGOMUKUM BEACH

A complete down fall in total foraminiferal number (TFN) and total species number (TSN) with reference to nearby unpolluted beaches like Quilon, Cochin, (unpublished data) Kanniyakumari were observed. A total of 11 species and 82 species per 5 g were encountered from Sangomukum beach.

Very low pH (1.4 to 2) indicates high acidic nature of effluents. Due to high acidity, the surface of some foraminiferal tests were found to be corroded (Plate 8).

CHAPTER 9

COMPARISON OF THE WEST WITH EAST COAST FORAMINIFERAL ASSEMBLAGE

Foraminiferal fauna of the East and West Coasts of India are characteristic warm water assemblages but their placement to the known foram-geographical provinces is a controversial problem.

Cushman (1950) originally classified the Recent warm-water foraminiferal fauna of the world into 4 main foram-geographical provinces, namely, East African, Indo-Pacific, West Indian and Mediterranean. According to him, West Coast of India falls within the East African and the East Coast in the Indo-Pacific province. However, a controversy cropped up with the advancement of our knowledge of the Recent foraminiferal assemblages of the Indian region. Bhatia (1956), Bhatia and Bhalla (1964), and Jain and Bhatia (1978) found that the Indo-Pacific elements dominate the foraminiferal assemblages of both the coasts. However, Bhalla, (1968, 1070) studied foraminifera from Vishakhapatnam and Marine beaches on the east coast and postulated that, "...there are probably two fairly distinct faunal provinces -

the Eastern, covering the major part of the Bay of Bengal and, the Western, covering the Arabian Sea" (Bhalla 1968, p. 388). He also discussed the role of oceanic currents in mixing of foraminiferal fauna of both the coasts. These observations were further supported by Boltovsky and Right (1976) and, Bhalla and Nigam (1979).

The above studies were based on a few beaches but no detailed comparison of foraminiferal fauna from shore sands of eastern and western India has yet appeared. In the present study, an attempt has been made to compare the foraminiferal assemblages from beaches covered by the present work with those described by earlier workers from the West as well as East Coast of India.

9.1 COMPARISON WITH THE REPORTS ON WEST COAST

Bhatia (1956) described 45 species from Juhu, Chaupatty, and Bhogat beaches from Western India and the following species occur in the present assemblage also: Textularia conica, T. foliacea, S. excavata, S. eximia, S. indica, Q. lamarckiana, Q. seminulum, Q. undulosa-costata, Q. venusta, Triloculina rotunda, T. rupertiana, T. terquimiana, T. tricarinata, Siphogenerina rephanus

Streblus annectens (=Ammonia annectens), Streblus papillosus (=A. papillosus), Strebles dentata (=Asterorotalia dentata), E. simplex, Poroeponides lateralis, Nonion seapha (= Florilus scaphus), Bolivina striatula, Bolivina variablis, Bulimina marginata and Loxostomum limbatum (=Bolivina limbatum). Rocha and Ubaldo (1964a) described 52 species from Diu, Gogola and Simbor beaches on the West coast and the following species are also found in the present assemblage : Quinqueloculina cf. lamarckiana, Q. pseudoreticulata, Q. undulosa-costata, Q. vulgaris, Spiroloculina eximia, S. indica, Triloculina terquemiana, T. tricarinata, T. trigonula, Siphogenerina rephanus, Luxostomum limbatum (=Bolivins limbatum), Diocorbis patielliformis (=Glabratella patelliformis), Eponides repandus, Poroeponides lateralis, Cibicides lobatulus, C. refulgens, Florilus scapha, Elphidium advena, E. craticulatum, E. crispum, E. indicum, E. simplex, Amphistegina radiata, Streblus annectens (=Ammonia annectens), Streblus dentata (=Asterorotalia dentata), Streblus pabillosus (=Ammonia papillosus), Streblus taiwanica (=Pararotalia nipponica). Rocha and Ubaldo (1964b) recorded 22 species from Jampore (Damao) and Baga (Goa) beaches also on the West Coast, and

Cibicides lobatulus, E. advena, E. craticulatum, E. indicum, Eponides repandus, Nonion boueanum, Florilus scapha, Poroeponides lateralis, Q. lamarkiana, Q. pseudoreticulata, Spiroloculina antilavium, Spiroloculina depressa, S. eximia, S. indica, Triloculina tricarinata, Streblus annectens (=Ammonia annectens), Streblus taiwanica (=Pararotalia nipponica), Streblus dentata (=Asterootalia dentata), Streblus popillosus (=Ammonia popillosus), are also common to the present study.

9.2 COMPARISON WITH THE REPORTS ON EAST COAST

Bhatia and Bhalla (1964) described 14 species of foraminifera from Puri beach sands. Out of these Q. seminulum, Triloculina trigonula, Streblus annectens (=Ammonia annectens), Streblus dentata (=Asterootalia dentata), Elphidium advena, E. simplex, Poroeponides lateralis, Nonion scapha (=Florilus scapha) also occur in our assemblage. From Vishakhapatnam beach, Bhalla (1968) reported 16 species and Ammonia dentata (=Asterootalia dentata), E. crispum, Quinqueloculina seminulum, Triloculina trigonula, E. advena, E. simplex, Poroeponides lateralis, Spiroloculina antillarium, S. communis, Triloculina terquemiana, T. tricarinata, Elphidiem indicum, E. minutum, are present in our material.

Species common to the present assemblage and the one found in Marina beach sand of Madras (Bhalla, 1970) are: *Quinqueloculina sominulum*, *Q. vulgaris*, *Ammonia annecteus*, *Pararotalia nipponica*, *Elphidium crispum*, *E. minutum*, *Poroeponides lateralis* and *Florilus scapha*.

9.3. DISCUSSION

Ammonia annectens and *Parorotalia nipoonica* which are abundant on the West Coast show rare occurrence on the East Coast, while *Quinqueloculina vulgaria*, *Asterorotalia dentata*, *Elphidium advena*, *E. minuta*, *E. indicum*, *Florilus scaphum* and *Spiroloculina communis* are abundant to rare on the west coast but occur rarely on the east coast. However, *Quinqueloculina semimulum* occurs commonly and *Spiroloculina antilearium*, *Triloculina tricarinata*, *T. terquemiana* and *Amphistegina medagascarensis* occur rarely on both the coasts. The following species which are abundant to rare on the West Coast have not been reported from the east coast of India: *Ammobaculites persicus*, *Textularia agglutinans*, *T. conica*, *T. foliacea*, *Trochammina hadai*, *Spiroloculina aequa*, *S. excavata*, *S. eximia*, *S. indica*, *S. planissima*, *S. rotunda*, *S. seita*, *S. tricarinata*, *Quinqueloculina agglutinata*, *Q.* cf. *Q. bicarinata*, *Q. bicornis*, *Q. kerimbatica*, *Q. lamarkiana*,

Q. laevigata, Q. ludurigi, Q. mediterranensis, Q. oblonga, Q. parkeri, Q. phoenica, Q. polygona, Q. pseudoreticulata, Q. rugosa, Q. andulosa costata, Q. venusta, Q. viennensis, Triloculina, insignis, T. loevigata, T. oblonga, T. rotunda, T. rupertiana, Miliolinella australis, Miliolinella oblonga, Lagena laevis, L. perlucida, L. vulgaris, Fissurina laevigata, Bolivina laevigata, B. cimbata, B. persiensis, B. striatula, B. variablis, Bulimina marginata, Uvigerina auberiana, Hopkinsina glabra, Siphogenerina rephanus, Cancris auricula, Glabratella pattelliformis, Pseudoeponides nakazotoensis, Ammonia indica, A. papillosus, A. sobrina, A. tepida, Pararotalia calcar. Elphidum craticulatum, E. diocoidale multiloulatum, E. macellum, Crotelphidium aff granosum, Globorotalia cultrata, Globigerina bulloides, Globigerinoides ruber, Globuquadrina dutertree, Eponides repandus, Poroeponides cribrorepandus, Amphistegina radiata, Cibicides lobatulus, C. refulgens, C. tenellus, Caribcanella indica, Fursenkonia pontoni, Nonin boueanum, Florilus elongatus, Hanzawaia concentrica, Asterorotalia inflata, Hyalinea balthica and Nummulites ammonoides.

Asterorotalia dentata and Elphideum crispum are abundant on the east coast but the former is abundant to rare and the latter is frequent to rare on the west coast. Likewise, *Elphidium simplex*, *Poroeponides lateralis* and *Triloculina trigonula* are commonly found on the east coast but occur rarely on the West Coast. *Ammonia hozanensis*, *Asterorotalia trispinosa*, *Pseudorotalia schroeteriana*, and *Quinqueloculina agglutinans* are the known Indo-Pacific species present on the East Coast but are totally absent from the west coast. However, *Ammonia annectens*, *Asterorotalia dentata* and *Pararotalia nipponica* are Indo-Pacific species which are common to both East and West Coast assemblages.

9.4 CLUSTER ANALYSIS OF FORAMINIFERAL FAUNA

As mentioned earlier, a controversy exists regarding the affinities of the foraminiferal assemblages of the East and West coasts, i.e., whether they belong to one or different foram-geographical provinces. In order to gain a better picture of the comparison for the East and West Coast foraminiferal assemblages, made earlier, it was considered desirable to check the available data by statistical method.

Amongst different statistical techniques, dendrogram based on cluster analysis is a modern method already successfully applied by foraminiferologists to solve a variety of problems, eg., biofacies analysis, taxonomic problems, etc. (Kaesler, 1966, Valentine

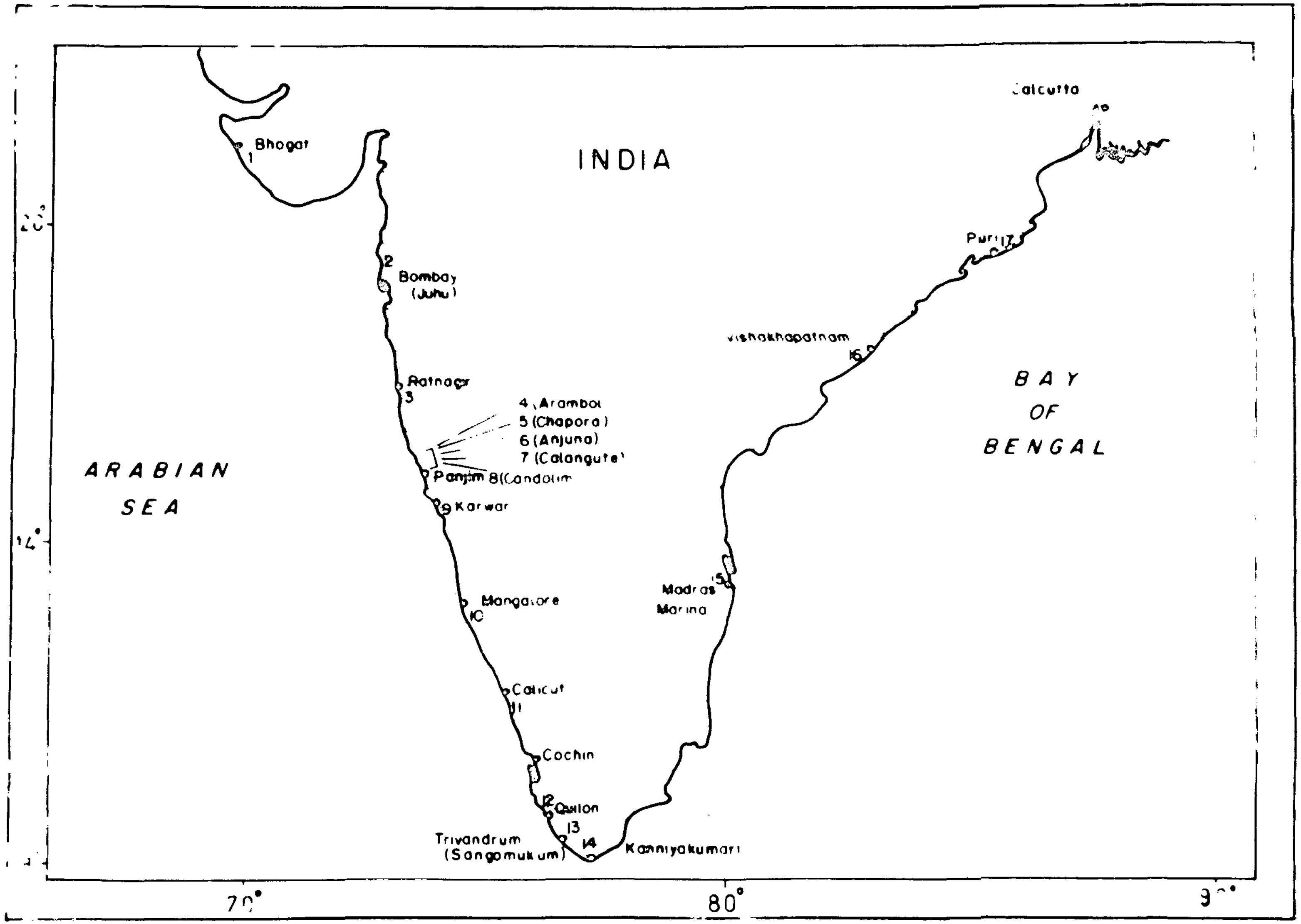


FIG._14 SHOWING STATION LOCATIONS REFERRED TO IN CLUSTER ANALYSIS OF FORAMINIFERAL FAUNA.

and Peddichord, 1967, Ujiie and Negase, 1971; Erskian and Lipps, 1978, Nigam and Sarupria, 1981). This method was therefore, used in the present study to compare the west coast foraminiferal assemblage with that from the east coast of India. The available data on foraminiferal distribution from beach sands of the east and west coasts has been subjected to Q. mode clusta analysis. Foraminiferal assemblages from the following 17 stations (Fig. 14) were considered for the present study:

A. WEST COAST

S. No.	Name of stations	Authors
1.	Bhogat beach (Gujarat)	Bhatia (1956)
2.	Juhu beach (Maharashtra)	Present study
3.	Ratnagiri beach (Maharashtra)	"
4.	Arambol beach (Goa)	"
5.	Chapora beach (Goa)	"
6.	Anjuna beach (Goa)	"
7.	Calangute beach (Goa)	"
8.	Candolim beach (Goa)	"
9.	Karwar beach (Karnataka)	"
10.	Mangalore beach (Karnataka)	"
11.	Calicut beach (Kerala)	"
12.	Quilon beach (Kerala)	"
13.	Sangomukum beach (Kerala)	"
14.	Kanniyakumari beach (Tamil Nadu)	"

B. EAST COAST

15.	Marina beach (Tamil Nadu)	Bhalla (1970)
16.	Vishakhapatnam (Andhra)	" (1968)
17.	Puri beach (Orissa)	Bhatia and Bhalla (1964)

Only those species which are common to at least two stations were used in cluster analysis. Thus, a total of 88 species from the above stations were selected (Appendix No. 4). The similarity matrix was obtained by using Jaccard Coefficient of association (Sj):

$$Sj = \frac{C}{N_1 + N_2 - C}$$

where C represents numbers of species common to two stations being compared; N_1, equals to the total species present in the first station; and N_2 equals to total species present in the second station (Chetham and Hazel, 1969). This coefficient essentially compares the number of positive matches between two stations to the sum of the positive matches plus mismatches. It ignores, however, negative matches and thus prevents a high degree of similarity occurring between stations which have a large number of absent species in common (Schafer and Scott, 1976). Values of association ranges from 0 (complete

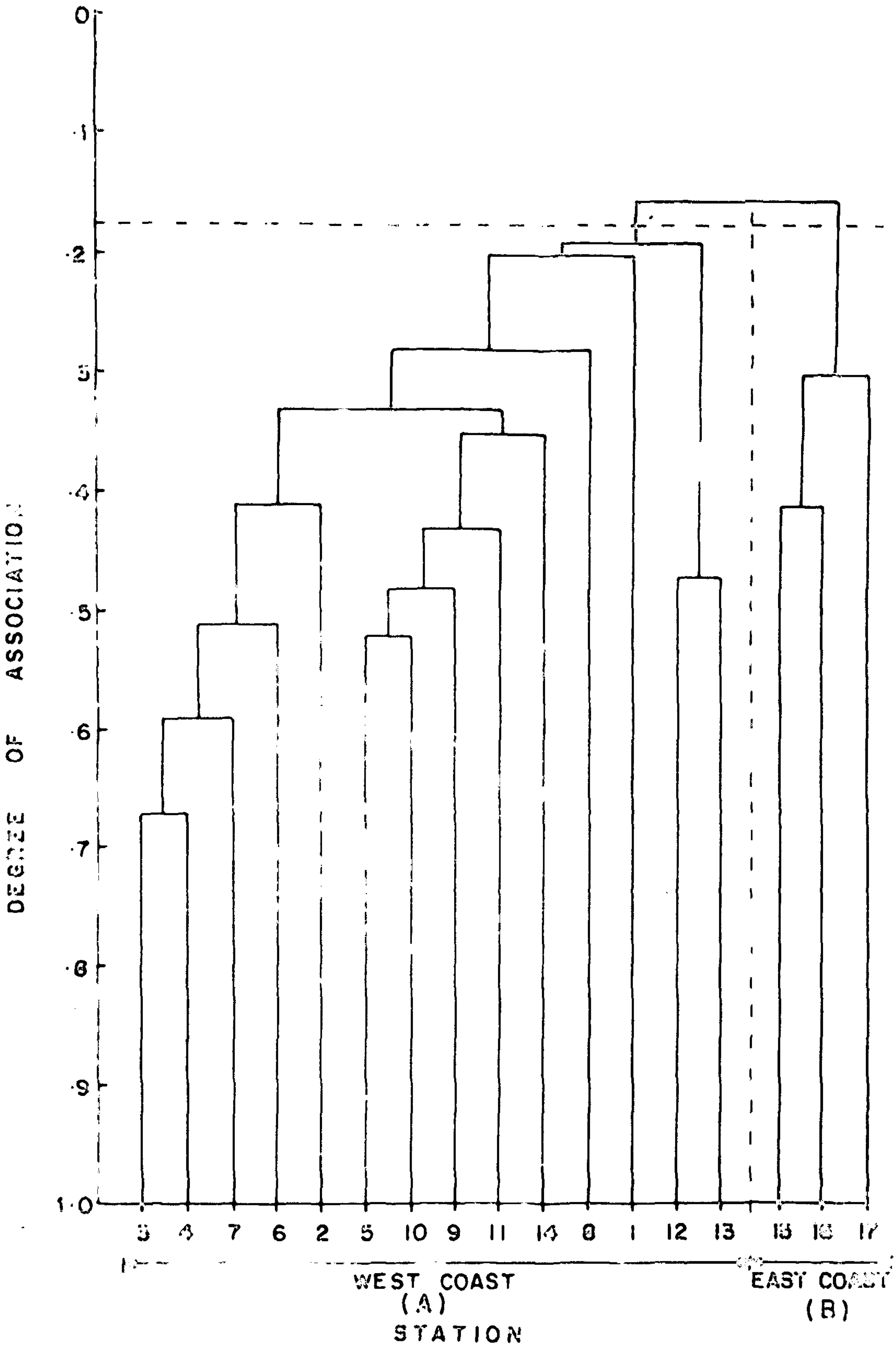


FIG._15 DENDROGRAM SHOWING RESULTS OF Q-MODE CLUSTER ANALYSIS OF FORAMINIFERAL FAUNA FROM BEACH SANDS OF THE EAST AND WEST COASTS OF INDIA.

dissimilarity) to 1 (complete similarity). After comparison of 17 stations in such a way, a matrix (of the order 17 x 17) was obtained consisting of 153 coefficients.

The clustering was then done upon this matrix using "Weighted pair group method with simple arithmetic average" as described by Sokal and Sneath (1963). On the basis of highest similarity, only one station has been permitted to join an other station or to other group in one clustering cycle, Matrics were recalculated for each cycle till the last member joins any group.

The final result of clustering was presented in the form of a two dimensional hierarchy dendrogram in which samples were listed along X-axis and degree of association along X-axis (fig. 15).

Cluster analysis of 17 stations and 88 species reveals 2 major biotopes at 0.175 level of association (fig. 15). Biotopes A and B are composed of 14 and 3 stations respectively. A glance at the geographical distribution of stations (fig. 14) shows that all the stations falling in biotopes A are from the west coast whereas those belonging to biotope B are from the east coast of India.

The above study shows that the foraminiferal assemblages of the east and west coasts belong to two different faunal realms and gives credence to the views expressed by earlier workers (Cushman, 1950, Bhalla, 1968, 1970; Boltoshy and Wright 1976; and Bhalla and Nigam, 1979).

Several authors have worked on the environmental parameters of the Arabian sea and the Bay of Bengal and have found them to be different from each other (Table 7). The differences in the east and the west coast foraminiferal assemblages may be due to these different ecological factors prevailing in the two regions and explains why the two fauna are not the same.

TABLE 7

COMPARISON OF VARIOUS ENVIRONMENTAL PARAMETERS FROM THE WATERS OF EAST AND WEST COASTS OF INDIA

S. No.	Parameter	East coast (Bay of Bengal)	West Coast (Arabian sea)	Authors
1.	Salinity	30 to 33 ‰	34 to 37 ‰	Panikar & Jayaraman (1960)
2.	Temperature	27 to 29°C	23 to 29°C	"
3.	Organic carbon	0.88 %	1.5 %	Wiseman & Bennett (1940)
4.	Biological Productivity			
a)	Surface production per unit area	High	Low	Qasim (1977)
b)	Column productivity	Low	High	

CHAPTER 10

CONCLUSIONS

The following conclusions have been drawn on the basis of the present study:

(i) The west coast of India is rich in foraminiferal assemblage and 4 new species are present.

(ii) The foraminiferal microfauna of the west coast shows decrease in total foraminiferal number (TFN) and total species number (TSN) from North to South along the coast. This latitudinal variation may be due to change in ecological parameters with latitude, viz., temperature, salinity, dissolved oxygen, nature of sediment, phosphorus, organic matter, etc., of the nearshore water.

(iii) Presence of relict and/or reworked foraminiferal tests along Kerala coast has been detected.

(iv) Acidic pollution causing catching of foraminiferal tests has been observed in case of Sangomukhum beach assemblage.

(v) Comparative study of the East and West Coast foraminiferal microfauna indicates that:

(a) The west coast microfauna is richer than the east coast microfauna.

(b) While on the west coast, the total foraminiferal number (TFN) and total species number (TSN) increase from south to north, the TFN and TSN increase from north to south on the East Coast of India.

(d) The foraminiferal assemblages of the East and the West Coasts belong to different foram-geographical provinces.

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PLATE 1

1. *Ammobaculites persicus* Lutze x 37.5
1a, apertural view; 1b, side view

2. *Trochammina hadai* Uchio x 37.5
2a, apertural view; 2b, side view

3. *Textularia conica* D'orbigny x 37.5
3a, apertural view; 3b, side view

4. *T. agglutinans* D'orbigny x 37.5
4a, apertural view; 4b, side view

5. *T. foliacea* Heron-Allen and Earland x 37.5
5a, apertural view; 5b, side view

6. *Spiroloculina communis* Cushman and Todd x 37.5
6a, apertural view; 6b, side view

7. *S. excavata* D'orbigny x 27
7a, side view; 7b, apertural view

8. *S. antillarium* D'orbigny x 60
8a, side view; 8b, apertural view

9. *S. scita* Cushman and Todd x 27
9a, side view; 9b, apertural view

10. *S. aequa* Cushman x 60
10a, apertural view, 10b, side view

11. *S. tricarinata* Terquem x 27
11a, apertural view; 11b, side view

12. <u>S. rotunda</u> D'orbigny x 27
12a, apertural view; 12b, side view

13. <u>S. planissima</u> Wiesner x 27
13a, side view; 13b, apertural view

14. <u>S. eximia</u> Cushman x 27
14a, side view; 14b, apertural view

15. <u>S. indica</u> Cushman and Todd x 37.5
15a, side view; 15b, apertural view

16. <u>Quinqueloculina</u> sp. x 60
16a, apertural view; 16b, side view

17. <u>Q. tropicalis</u> Cushman x 60
17a, 4-Chambered view; 17b, 3-Chambered view

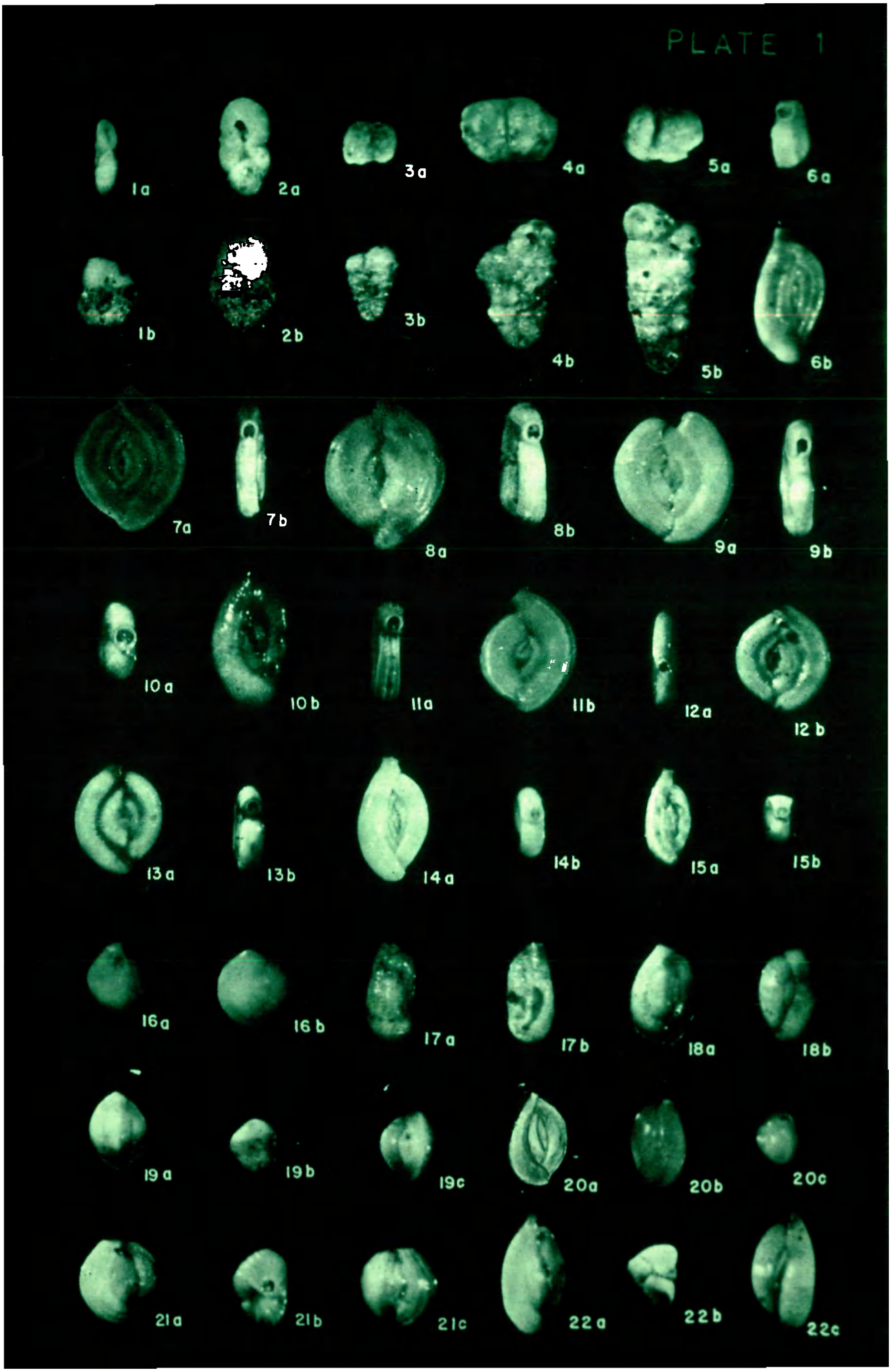
18. <u>Q. seminulum</u> (Linne) x 37.5
18a, 4-Chambered view; 18b, 3-Chambered view

19. <u>Q. vulgaris</u> D'orbigny x 37.5
19a, 4-Chambered view; 19b, apertural view;
19c, 3-Chambered view

20. <u>Q. ludwigi</u> Reuss x 37.5
20a, 4-Chambered view, 20b, 3-Chambered view
20c, apertural view

21 <u>Q. bicornis</u> (Walker and Jacob) x 37.5
21a, 4-Chambered view, 21b, apertural view;
21c, 3-Chambered view

22 <u>Q. schlumbergeri</u> (Wiesner) x 37.5
22a, 4-Chambered view, 22b, apertural view;
22c, 3-Chambered view.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22c

PLATE 2

1. *Quinqueloculina pseudoreticulata* Parr x 37.5
   1a, 4-chambered view; 1b, apertural view;
   1c, 3-chambered view

2. *Q. kerimbatica* (Heron-Allen and Earland) x 60
   2a, 4-chambered view; 2b, apertural view
   2c, 3-chambered view

3. *Q. bicarinata* D'orbigny x 60
   3a, 4-chambered view; 3b, apertural view;
   3c, 3-chambered view

4. *Q. rugosa* D'orbigny x 37.5
   4a, 4-chambered view; 4b, apertural view;
   4c, 3-chambered view

5. *Q. lamarkiana* D'orbigny x 60
   5a, 4-chambered view; 5b, apertural view;
   5c, 3-chambered view

6. *Q. undulosa costata* Terquem x 37.5
   6a, 3-chambered view; 6b, apertural view
   6c, 4-chambered view

7. *Q.* aff. *Q. viennensis* Le'Calvez x 37.5
   7a, 4-chambered view; 7b, apertural view;
   7c, 3-chambered view

8. *Q. hagni* n. sp. x 37.5
   8a, 3-chambered view; 8b, apertural view;
   8c, 4-chambered view.

9. *Q.* sp. x 37.5

9a, 3-chambered view; 9b, apertural view;
9c, 4-chambered view

10. *Q.* *venusta* Karrer x 37.5

10a, 4-chambered view; 10b, apertural view;
10c, 3-chambered view

11. *Q.* *singhi* n. sp. x 37.5

11a, 4-chambered view, 11b, apertural view;
11c, 3-chambered view

12. *Q.* *oblonga* (Montagu) x 37.5

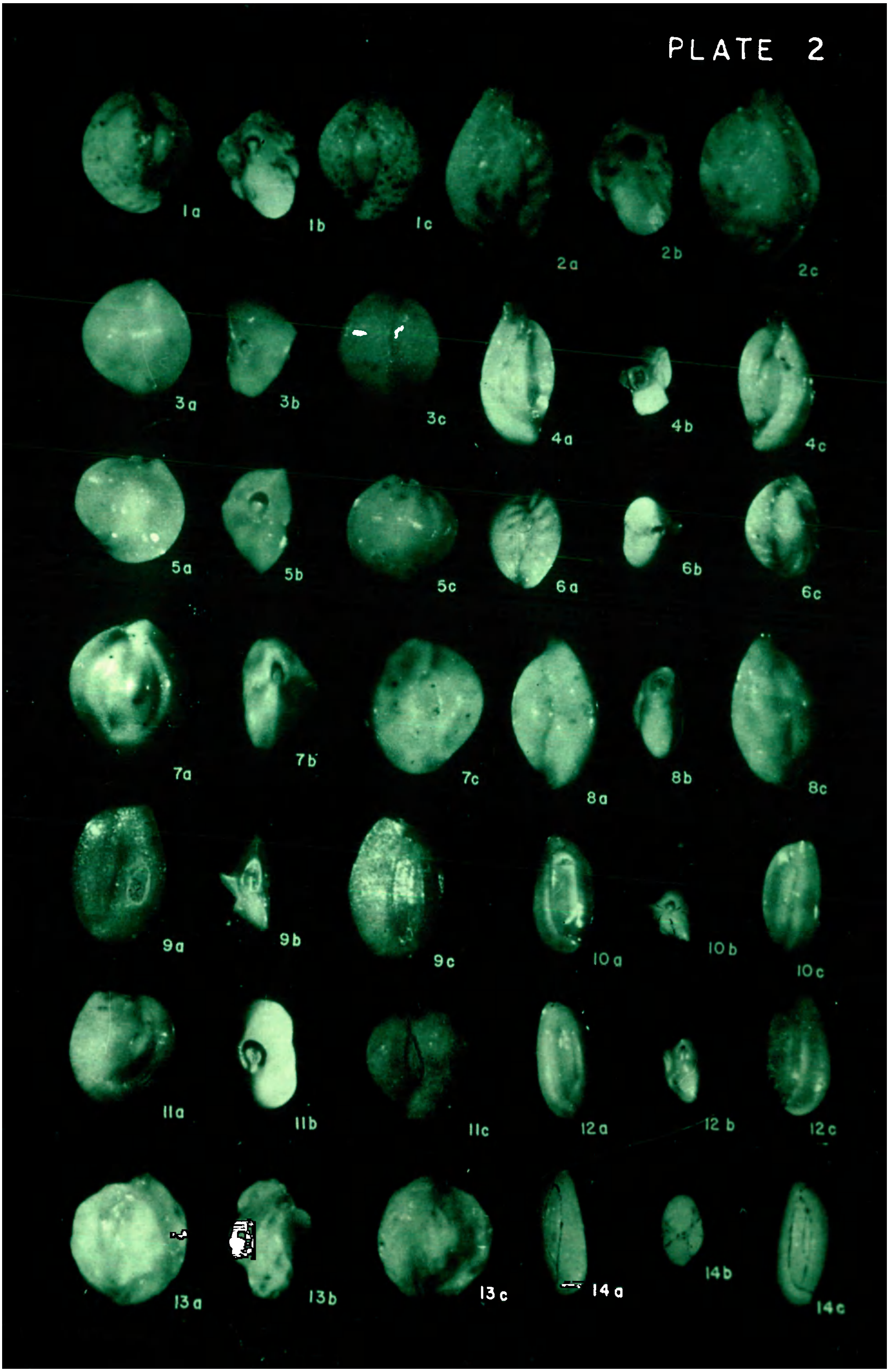
12a, 4-chambered view; 12b, apertural view;
12c, 3-chambered view

13. *Q.* *parkeri* (Brady) x 75

13a, 4-chambered view; 13b, apertural view;
13c, 3-chambered view

14. *Q.* *laevigata* D'orbigny x 60

14a, 3-chambered view; 14b, apertural view;
14c, 4-chambered view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14b
14c

PLATE 3

1. <u>Quinqueloculina phoenica</u> colom x 60
   1a, 4-chambered view; 4b, apertural view;
   1c, 3-chambered view

2. <u>Q. polygona</u> D'orbigny x 75
   2a, 4-chambered view; 2b, apertural view;
   2c, 3-chambered view

3. <u>Q. agglutinata</u> Cushman x 37.5
   3a, 4-chambered view; 3b, apertural view;
   3c, 3-chambered view

4. <u>Q. mediterranensis</u> Le Calvez x 60
   4a, 4-chambered view; 4b, apertural view;
   4c, 3-chambered view

5. <u>Triloculina</u> Aff. <u>T. echinata</u> D'orbigny x 60
   5a, 4-chambered view; 5b, apertural view;
   5c, 3-chambered view

6. <u>T. tricarinata</u> D'orbigny x 37.5
   6a, apertural view; 6b, side view

7. <u>T. laevigata</u> D'orbigny x 37.5
   7a, 3-chambered view; 7b, 2-chambered view

8. <u>T. rupertiana</u> (Brady) x 37.5
   8a, 2-chambered view; 8b, apertural view;
   8c, 3-chambered view

9. <u>T. oblonga</u> (Montagu) x 60
   9a, 3-chambered view; 9b, apertural view;
   9c, 2-chambered view

10. *T. terquemiana* (Brady) x 37.5
10a, 3-chambered view; 10b, 2-chambered view,
10c, apertural view.

11. *T. trigonula* (Lamark) x 60
11a, 3-chambered view; 11b, 2-chambered view

12. *T. rotunda* D'orbigny x 37.5
12a, 3-chambered view; 12b, apertural view;
12c, 2-chambered view

13. *T. insignis* (Brady) x 60
13a, 3-chambered view, 13b, apertural view,
13c, 2-chambered view

14. *T. qasimi* n. sp. x 60
14a, 3-chambered view, 14b, apertural view,
14c, 2-chambered view

PLATE 3

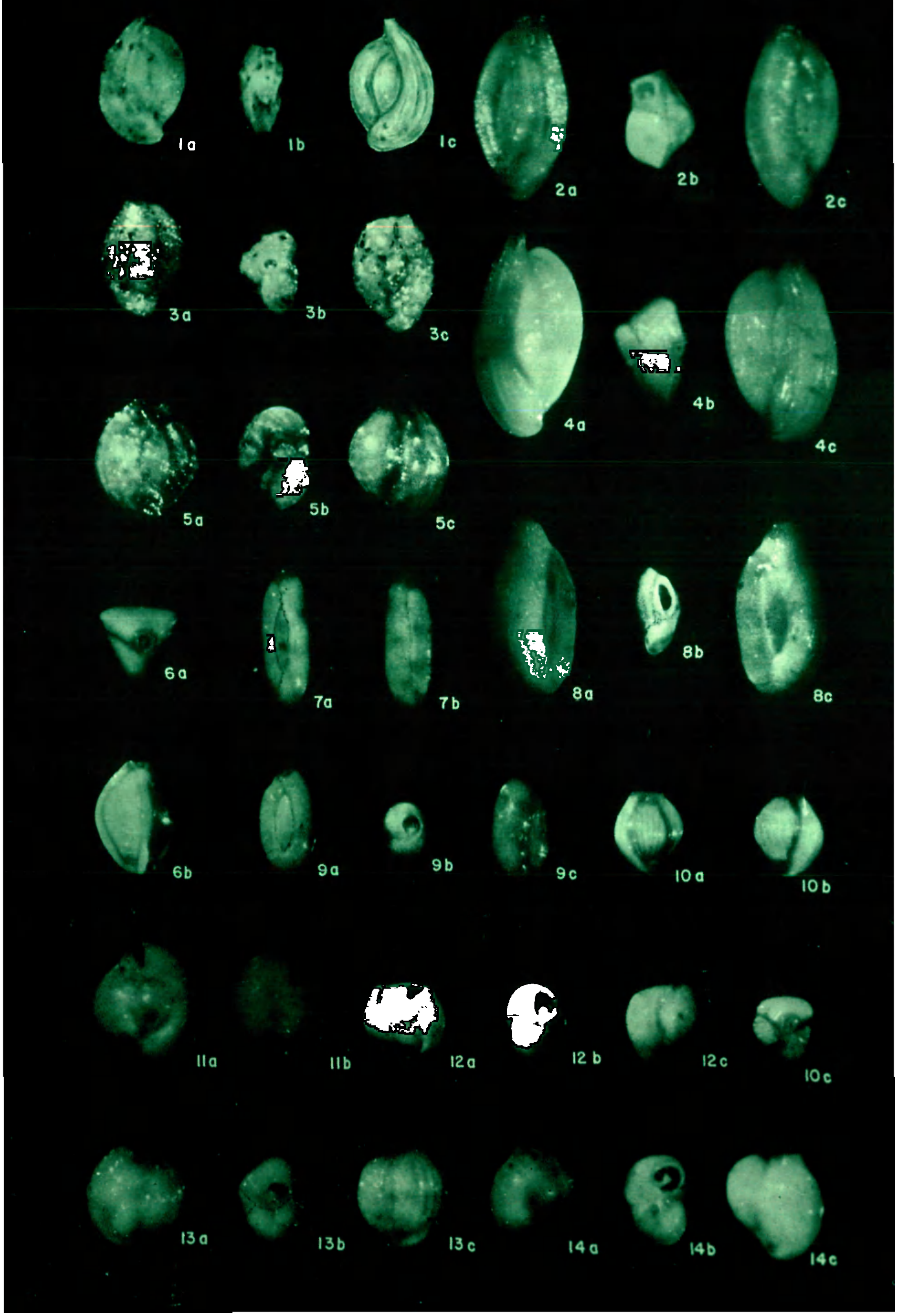
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PLATE 4

1. *Miliolinella australis* (Parr) x 60
   1a, side view, 1b, apertural view

2. *M. oblonga* (Montagu) x 60
   2a, 4-chambered view; 2b, apertural view,
   2c, 3-chambered view

3. *Siphogenerina rephanus* (Parker and Jones) x 37.5
   3a, curved specimens, 3b, normal specimen

4. *Lagena perlucida* (Montagu) x 37.5

5. *L. vulgaris* Williamson x 37.5

6. *L. semistriata* Williamson x 37.5

7. *L. laevis* (Montagu) x 37.5

8. *Fissurina laevigata* Reuss x 60

9. *Bolivina persiensis* Lutze x 60
   9a, microspheric form; 9b, megalospheric form

10. *B. limbata* (Brady) x 60
    10a, meglospheric form, 10b, microspheric form

11. *B. striatula* Cushman x 60
    11a, megalospheric form; 11b, microspheric form

12. *B.* cf. *B. variabilis* (Williamson) x 60
    12a, megalospheric form; 12b, microspheric form

13. *B. laevigata* (Williamson) x 60

14. *Nodosaria* sp x 60

15. *Bulimina marginata* D'orbigny x 60

16. *Uvigerina auberiana* D'orbigny x 60
16a, side view; 16b, apertural view,
16c, side view

17. *Hopkinsina glabra* (Millet) x 60
17a, apertural view; 17b, side view

18. *Cancris auricula* (Fichtel and Moll) x 60
18a, ventral view; 18b, apertural view;
18c, dorsal view

19. *Glabratella* sp. x 60
19a, dorsal view; 19b, apertural view;
19c, ventral view

20. *G. patelliformis* (Brady) x 60
20a, ventral view; 20b, apertural view;
20c, dorsal view

21. *Pseudoeponides nakazotoensis* (Kuwano) x 60
21a, dorsal view; 21b, apertural view;
21c, ventral view

22. *Ammonia sobrina* (Shupack) x 60
22a, dorsal view; 22b, apertural view;
22c, ventral view

23. *A. tepida* (Cushman) x 60
23a, ventral view; 23b, apertural view;
23c, dorsal view

24. *A. annectens* (Parker and Jones) x 37.5
megalospheric form
24a, ventral view; 24b, apertural view;
24c, dorsal view

25. *A. annectens* (Parker and Jones) x 37.5
microspheric form
25a, dorsal view; 25b, apertural view;
25c, ventral view.

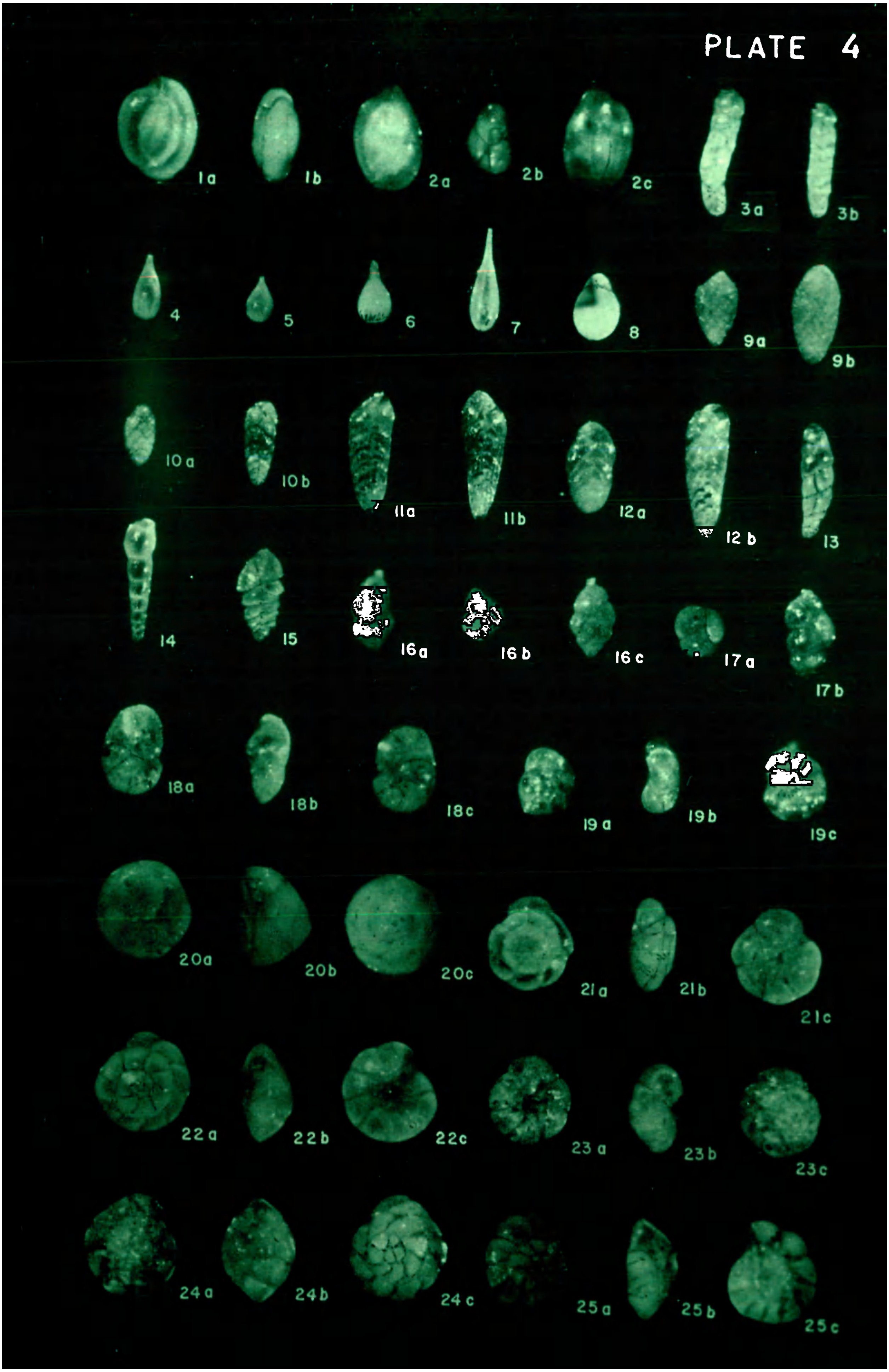
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PLATE 5

1. *Ammonia papillosus* (Brady) x 37.5
   megalospheric form
   1a, ventral view; 1b, apertural view;
   1c, dorsal view

2. *A. papillosus* (Brady) x 37.5
   microspheric forms
   2a, ventral view; 2b, apertural view;
   2c, dorsal view

3. *A. indica* (Le Roy) x 37.5
   3a, ventral view; 3b, apertural view;
   3c, dorsal view

4. *Asterorotalia dentata* (Parker and Jones) x 60
   4a, dorsal view of megalospheric form;
   4b, ventral view of microspheric form;
   4c, apertural view of microspheric form;
   4d, dorsal view of microspheric form

5. *A. inflata* (Millet) x 75
   5a, dorsal view; 5b, apertural view;
   5c, ventral view

6. *Globorotalia cultrata cultrata* (D'orbigny) x 60
   6a, ventral view; 6b, apertural view;
   6c, dorsal view

7. *Globigerina bulloides* D'orbigny x 60
   7a, ventral view; 7b, apertural view;
   7c, dorsal view

8. Globigerinoides ruber (D'orbigny) x 37.5
8a, ventral view; 8b, dorsal view;
8c, apertural view

9. Globoquadrina dutertrei (D'orbigny) x 60
9a, ventral view; 9b, dorsal view;
9c, apertural view

10. Pararotalia calcar D'orbigny x 60
10a, ventral view; 10b, dorsal view;
10c, apertural view

11. P. minuta (Takayanagi) x 37.5
11a, dorsal view; 11b, ventral view

12. P. nipponica (Asano) x 60
microspheric form - 12a, dorsal view;
12b, apertural view; 12c, ventral view;
megalospheric view- 12d, dorsal view

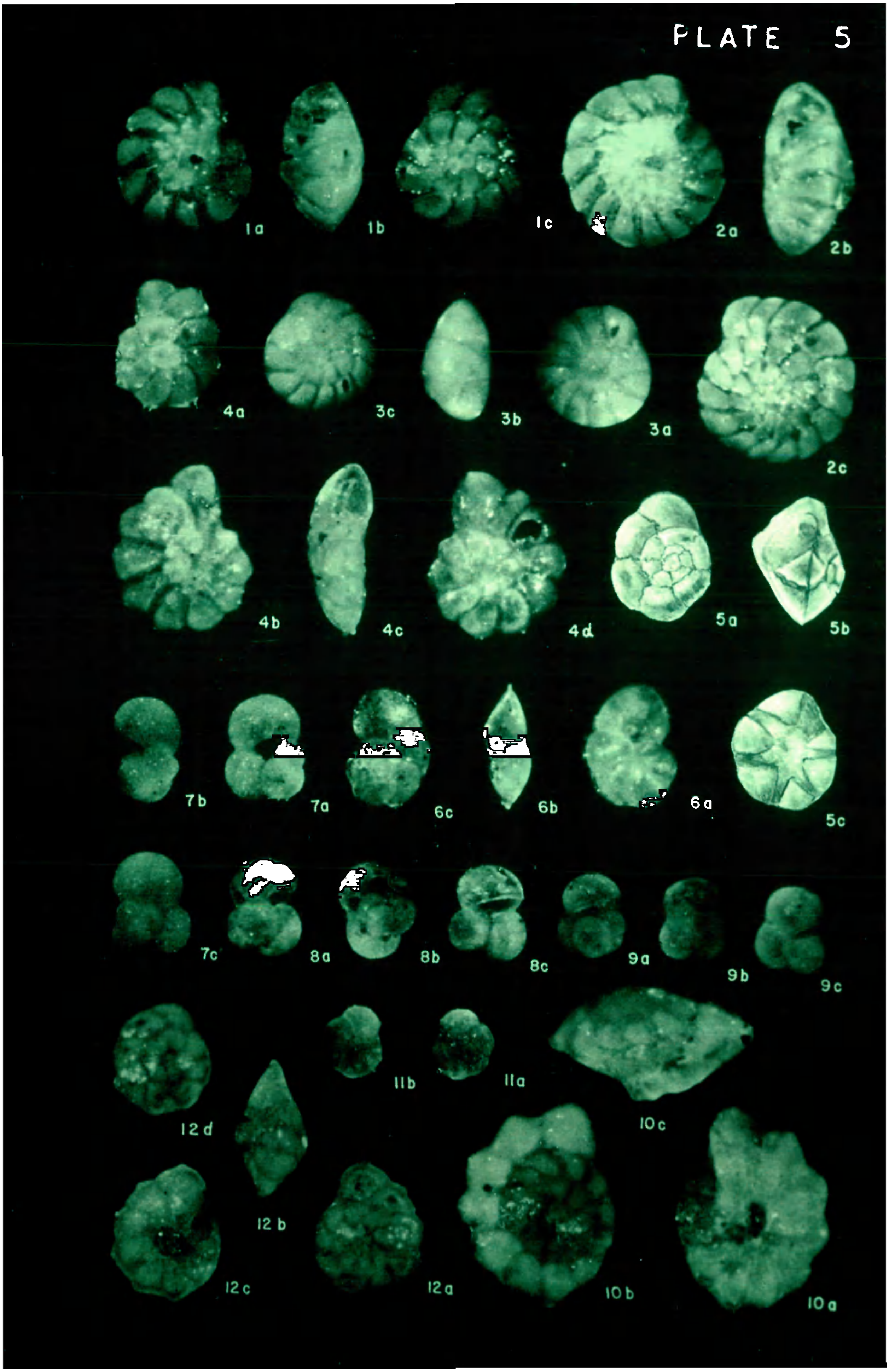
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PLATE 6

1. _Elphidium advenum_ (Cushman) x 60
1a, side view; 1b, apertural view

2. _E. crispum_ (Linne) x 60
2a, side view; 2b, apertural view

3. _E. indicum_ Cushman x 60
3a, side view; 3b, apertural view

4. _E. advenum_ var. (Cushman) x 60
4a, apertural view; 4b, side view

5. _E. discoidale multiloculatum_ Cushman and Ellisore x 60
5a, apertural view; 5b, side view

6. _E. minutum_ (Reuss) x 60
6a, side view; 6b, apertural view

7. _F. craticulatum_ (Fichtel and Moll) x 60
7a, side view; 7b, apertural view

8. _E. macellum_ (Fichtel and Moll) x 60
8a, side view; 8b, apertural view

9. _E. simplex_ Cushman x 60
9a, apertural view; 9b, side view

10. _E._ Sp. x 60
10a, apertural view; 10b, side view

11. _Protelphidium_ aff. _P. granosum_ (D'orbigny) x 60
11a, apertural view; 11b, side view

12. *Cribroelphidium* sp. x 60
12a, apertural view; 12b, side view

13. *Florilus scaphus* (Fichtel and Moll) x 60
13a, apertural view; 13b, side view

14. *Nonion* sp. x 60
14a, apertural view; 14b, side view

15. *F. elongatus* (D'orbigny)
15a, apertural view; 15b, side view

16. *N. boueanum* (D'orbigny) x 60
16a, apertural view, 16b, side view.

PLATE 6

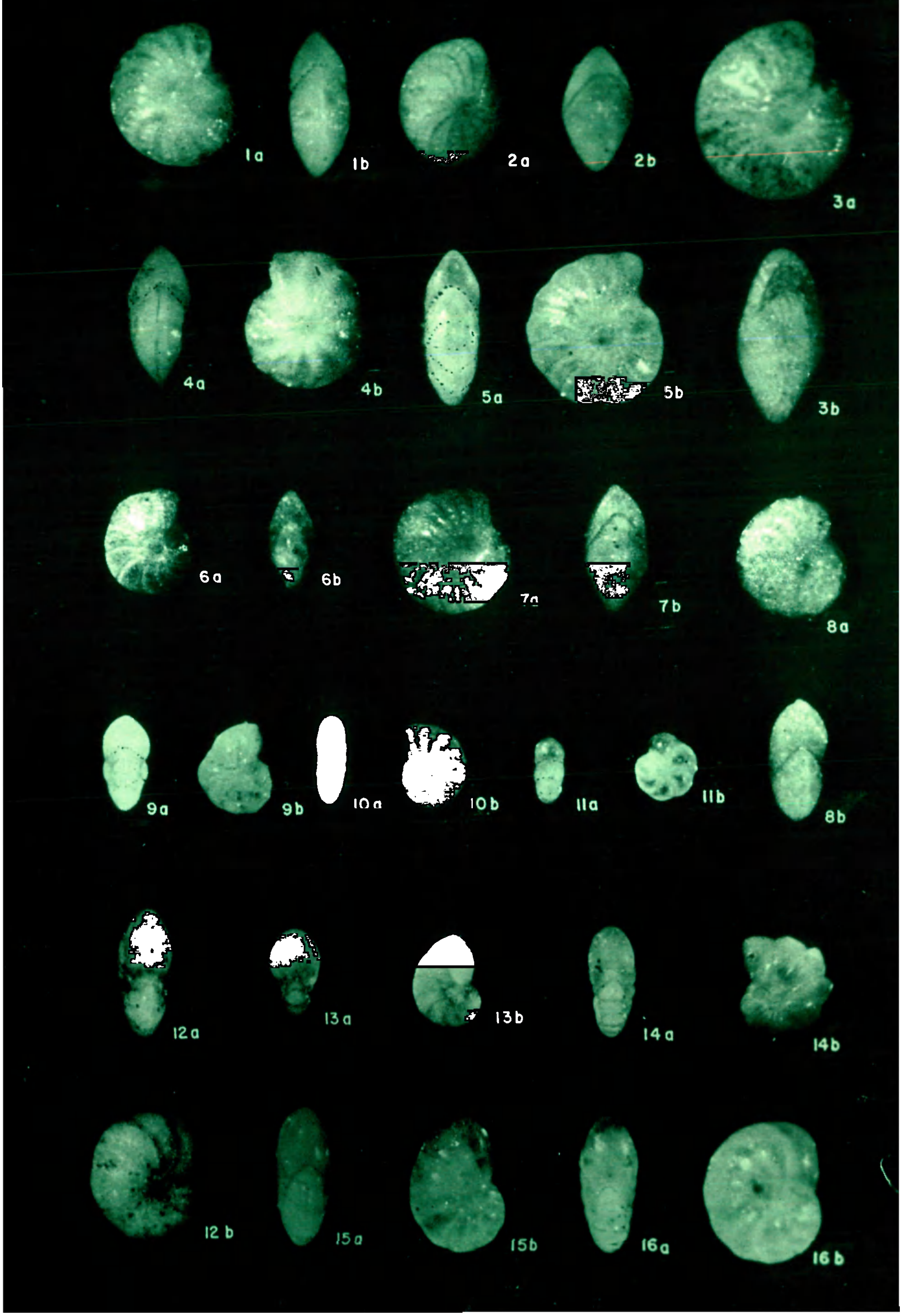
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PLATE 7

1. <u>Eponides</u> <u>repandus</u> (Fichtel and Moll) x 37.5
   1a, ventral view; 1b, apertural view;
   1c, dorsal view

2. <u>Poroeponides</u> <u>cribrorepandus</u> (Aeano and Uehio)
   x 37.5 Megalospheric forms
   2a, apertural view; 2b, ventral view;
   2c, dorsal view

3. <u>P.</u> <u>cribrorepandus</u> (Asano and Uchio) x 37.5
   Microspheric forms
   3a, apertural view; 3b, dorsal view

4. <u>P.</u> <u>lateralis</u> (Terquem) x 37.5
   4a, ventral view; 4b, dorsal view

5. <u>Fursenkonia</u> <u>pontoni</u> (Cushman) x 60

6. <u>Hyalinea</u> <u>balthica</u> (Schröter) x 30
   6a, apertural view; 6b, side view

7. <u>Amphistegina</u> <u>radiata</u> (Fichtel and Moll) x 37.5
   7a, ventral view; 7b, dorsal view

8. <u>Nummulites</u> <u>ammonoides</u> (Gronovius) x 37.5
   8a, side view; 8b, apertural view

9. <u>A.</u> <u>madagascariensis</u> D'orbigny x 37.5
   9a, dorsal view; 9b, apertural view;
   9c, ventral view

10. <u>Cibicides</u> <u>lobalulus</u> (Walker and Jocob) x 60
    10a, ventral view; 10b, apertural view;
    10c, dorsal view

11. *C. refulgens* Montfort x 60
11a. ventral view; 11b, apertural view;
11c, dorsal view

12. *C. tenellus* (Reuss) x 60
12a, ventral view; 12b, apertural view;
12c, dorsal view

13. *Hanzawaia concentrica* (Cushman) x 60
13a, ventral view; 13b, apertural view;
13c, dorsal view

14. *Cibicides* sp x 60
14a, dorsal view; 14b, apertural view;
14c, ventral view

15. *Caribeanella indica* n. sp.
15a, ventral view; 15b, apertural view;
15c, dorsal view

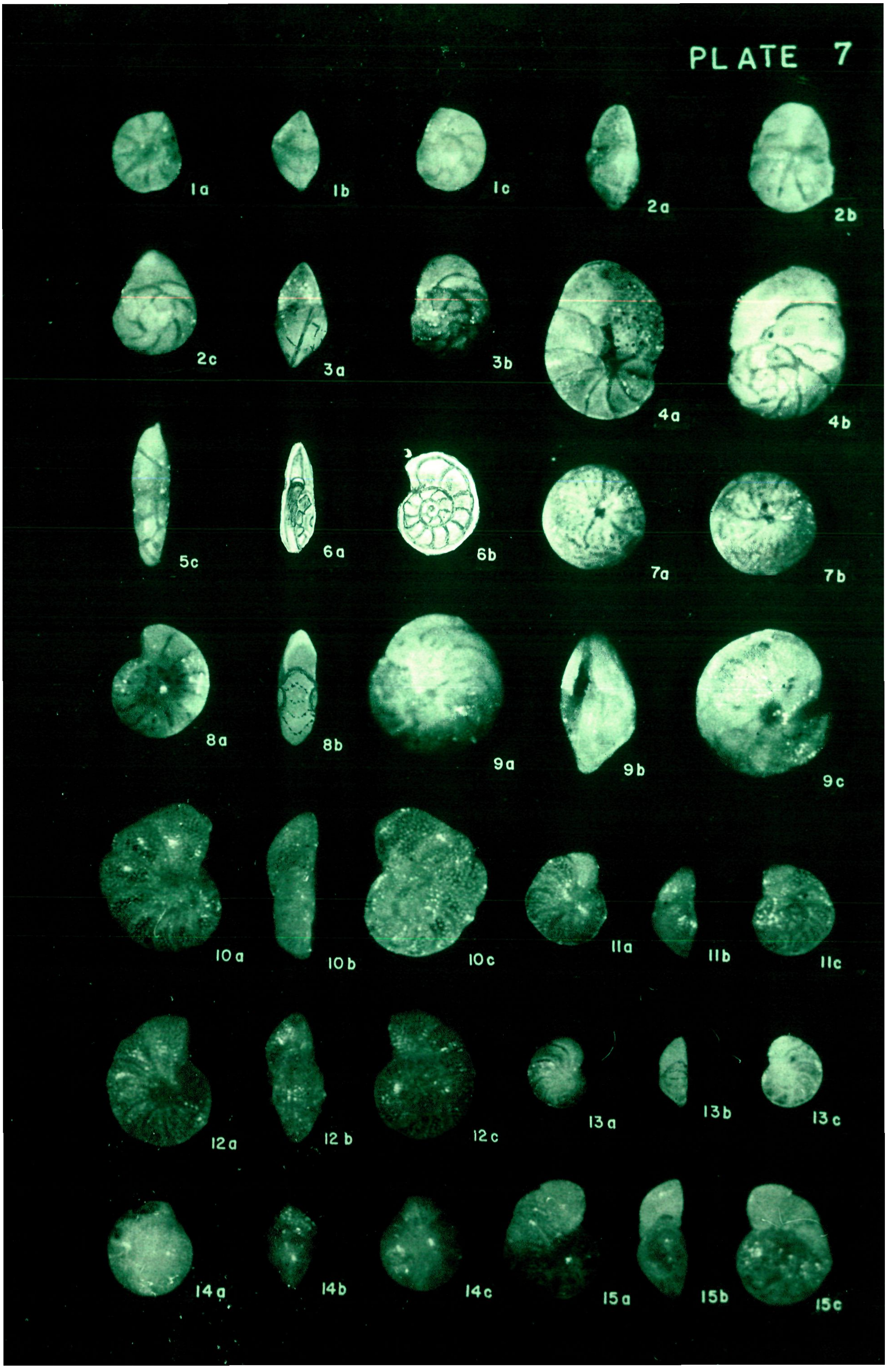
PLATE 7
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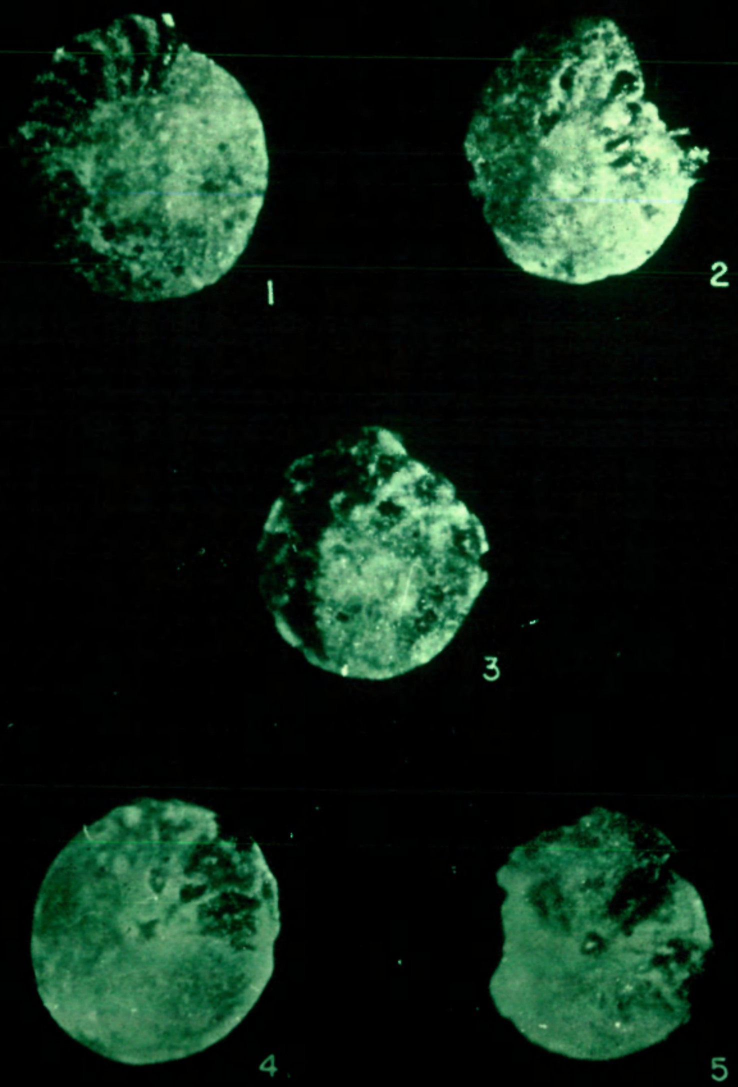
PLATE 8

Fig. 1	*Elphidium craticulatum*	x 60
2	*E. craticulatum*	x 60
3	*Ammonia* sp.	x 60
4	*Amphistegina madagascariensis*	x 30
5	*A. madagascariensis*	x 30

PLATE 8



APPENDIX 1

Values of different sieve fractions obtained for grain size analysis of different beach sand

S.No.	Name of Stations	Weight (in gm) in Sieve No										
		10	14	18	25	35	45	60	80	120	170	Pan
1.	Juhu	0.0659	0.1266	0.5101	1.1632	2.8909	4.5893	5.5691	2.2678	5.1580	1.9098	0.9312
2.	Ratnagiri	1.7987	0.4192	0.6502	0.4504	1.6797	4.1492	6.1118	2.5822	5.6040	1.7387	0.0537
3.	Arambol	1.4094	0.0226	0.0321	0.0322	0.1318	0.5225	3.6529	5.6951	11.3707	1.9482	0.2957
4.	Chapora	0.7770	0.0008	0.0007	0.0026	0.0062	0.0070	4.6160	9.1489	9.6478	0.6313	0.0540
5.	Anjuna	0.5280	0.3080	0.6080	0.5136	1.0691	2.8702	9.3073	5.7650	4.0776	0.0579	0.0073
6.	Calangute	0.4108	0.4477	0.9973	1.4819	6.6605	6.5773	4.4090	2.3470	1.6731	0.0216	0.0027
7.	Candolim	1.4663	0.8585	2.3033	1.6999	5.9155	5.2952	4.8287	1.9729	0.5922	0.0165	0.0011
8.	Karwar	0.2275	0.0467	0.1441	0.2141	1.2730	2.7272	5.8624	4.7719	8.6719	1.0156	0.0497
9.	Mangalore	0.8546	0.3360	0.8213	0.9300	4.1740	5.8850	6.4557	2.9590	2.1990	0.0140	0
10.	Calicut	0.1340	0.1181	0.3580	0.6960	2.6755	4.8985	7.6050	3.6325	4.3180	0.2325	0.0097
11.	Quilon	0.9251	1.1881	3.5281	3.0602	7.5979	6.0266	2.3189	0.2776	0.0811	0.0029	0
12.	Sangomukan	0	0.0110	0.0480	0.2198	3.1574	9.5953	9.7495	1.6958	0.4408	0.0114	0
13.	Kanniyakumari	0.0894	0.0295	0.0395	0.0525	0.4120	3.7923	11.6942	4.8675	4.1003	0.4255	0.0150

APPENDIX - 2

FORTRAN IV PROGRAM FOR GRAIN SIZE ANALYSIS

```
      PROGRAM GRAINSIZE GRAPHIC METHOD
      DIMENSION C (25),W(25),PH(25),CP(25),CPH(25),
      WP(25),W(100)
      1,P(26,51),A(51)
      DATA STAR,DO1,BLANK/'*','.',1H/
      DO 909 I=1,51
      DO 909 J=1,51
  909 P(I,J)=BLANK
      NI=27
      N2=25
      DO 910 I=1,25
      N1=N1-1
      N2=N2+1
      P(I,N1)=DOI
  910 P(I,N2)=DO1
      DO 911 J=1,51,2
  911 P(26,J)=DO1
  701 WRITE(8,10)
      WRITE(8,18)
    1 FORMAT(A2,A2,A3,12,F6.4,F4.0,F3.0)
    2 FORMAT(5X,'SHIP NAME=',A2,5X,'TRACK/CRUISE
      NO.=',A2,5X,'SAMPLE NO. =',A3,//,5X,'TOTAL
      WEIGHT=',F8.4,5X,'NO. OF PHI VALUES '12,5X,'PH
      (1)=',F4.0,5X,'PHD=I,F4.2,2X,'ACTUAL WEIGHT =
      ',F8.4,//)
    3 FORMAT(7X,'PH(I)',8X,'W(I)',9X,'WP(I)',8X,
      'C(I)',13X,'CP(J)',10X,' CPH(J)',/)
    4 FORMAT(12F6.4)
    5 FORMAT(4(5X,F8.4),10X,F8.4,5X,E14.6)
    6 FORMAT(62X,F8.4,5X,E14.6)
    7 FORMAT (4(5X,F8.4))
```

```
      8 FORMAT(10X,'GRAPHIC MEAN MZ=',15X,E14.6,/,10X,
        'GRAPHIC STANDARD DEVIATION=', 4X,E14.6,10X,'SAND
        PERCENT=',5X,F8.4,/,10X,'GRAPHIC SKEWNESS=',14X,
        E14.6,10X,'SILT PERCENT=',5X,F8.4,/,10X,'GRAPHIC
        KURTOSIS=',14X,E14.6,10X,'CLAY PERCENT=',5X,F8.4,/,
        10X,'GRAPHIC NORMALISED KURTOSIS=',3X,E14.6,/)
     10 FORMAT(1H1,//)
     11 FORMAT(5X,//,10X)
     17 FORMAT(10X,'PHI MEAN SIZE=',E14.6,5X,'PHI STANDARD
        DEVIATION=',E14.6,5X,'PHI SKEWNESS=',E14.6)
    702 READ(7,1)SH,TR,SNO,M,WW,PH(1),PHD
     18 FORMAT(   85X,'*INDIAN NATIONAL OCEANOGRAPHIC
        DATA CENTRE-JS*',//)
        IF(M.EQ.0) GO TO  300
        READ(7,4) (W(1),I=1,M)
        WM=0
        DO 15 I=1,M
     15 WM=WM+W(I)
     19 WRITE(8,2)SH,TR,SNO,WW,M,PH(1),PHD,WM
        WP(I)=(W(1)*100)/WM
        C(1)=WP(I)
        DO 12 I=2,M
        11=I-1
        PH(I)=PH(II)+PHD
        WX=W(I)*100
        WP(I)=WX/WM
        C(I)=C(I1)+WP(I)
     12 CONTINUE
     13 CP(1)=1.0
        CP(2)=5.0
        CP(3)=16.0
        CP(4)=25.0
        CP(5)=50.0
        CP(6)=75.0
```

```
      CP(7)=84.0
      CP(8)=95.0
      SAND=0.0
      SILT=0.0
      CLAY=0.0
      I=0
  713 I=I+1
      IF(I.GT.M)GO TO 721
      IF(P H(I)-4.0)711,711,712
  711 SAND=SAND+WP(I)
      GO TO 713
  712 IF (PH(I)-8.0)714,714,715
  714 SILT=SILT+WP(I)
      GO TO 713
  715 CLAY=CLAY+WP(I)
      GO TO 713
  721 J=I
      I=0
   71 I=I+I
      IF(I.EQ.(M+I)) GO TO 79
   70 IF (C(I)-CP(J)) 71,72,73
   72 CPH(J)=PH (I)
      GO TO 78
   73 IF(I-2) 74,75,76
   74 IF(C(I).GT.5) GO TO 77
      CPH(J)=0
      GO TO 78
   77 CPH(I)=0.0
      CPH(2)=PH(I)+(PH(I)-PH(2))*(CP(2)-C(I))/(C(1)-C(2))
      J=2
      GO TO 78
   75 CALL LAGIN2(C(I-1),C(I),PH(I-1),PH(I),CP(J),CPH(J))
      GO TO 78
```

```
      76 CALL LAGIN3 (C(I-2),C(I-1),C(I),PH(I-2),
         PH(I-1),Ph(I),CP(J),CPH(J)
        1)
         IF (CPH(J).LT.C(I-1)) GO TO 75
         IF(CPH(J).GT.C(I-1)) GO TO 75
      78 J=J+1
         IF(J.LE.8) GO TO 70
      79 WRITE(8,3)
         IF(M-8)91,92,93
      91 WRITE(8,5)(PH(I),W(I),WP(I),C(I),CP(I),
         CPH(I),I=1,M)
         N=M+1
         WRITE(8,6)(CP(I),CPH(I),I=N  ,8)
         GO TO 95
      92 WRITE(R,5)(PH(I),W(I),WP(I),C(I),CP(I),
         CPH(I),I=1,8)
         GO TO 95
      93 WRITE(8,5)(PH(I),W(I),WP(I),C(I),CP(I),CPH(I),
         I=1,8)
         WRITE(8,7)(PH(I),W(I),WP(I),C(I),1=9
      95 GZ1=(CPH(3)+CPH(5)+CPH(7))
         GMZ=G71/3.
         G1=CPH(7)-CPH(3)
         G2=CPH(8)-CPH(2)
         GSD=G1/4+G2/6.6
         SKI=(GZ1-3*CPH(5))/(2*G1)
         SK2=(CPH(2)+CPH(8)-2*CPH(5))/(2*G2)
         GSK=SK1+SK2
         GKG=G2/(2.44*(CPH(6)-CPH(4)))
         GNKG=GKG/ (1+GKG)
         WRITE (8,11)
         WRITE (8,8)GMZ,GSD,SAND,GSK,SILT,GKG,CLAY,GNKG
         AMP=(CPH(3)+CPH(7))/2.
```

```
      DP=GI/2.
      SP=SK1*2
      WRITE(8,17)AMP,DP,SP
      WRITE(8,11)
      CALL CLASS(SAND,SILT,CLAY)
      WRITE(8,1712)
 1712 FORMAT(45X,'CUMULATIVE FREQUENCY CURVE',//,
      51X,'C(I)',/)
   94 DO 706 I=1,101
  706 Q(I)=DOT
      DO 707 I=1,101,10
      DO 707 I=1,101,10
  707 Q(I)=STAR
      NN=1
      NN2=M/2+1
  710 WRITE(8,708)(Q(I),I=1,101)
  708 FORMAT(15X,101A1,/,15X,'.')
 1715 DO 709 I=2,101
  709 Q(I)=BLANK
      NOP=C(NN)+0.35+1.
      Q(NOP)=STAR
      NN=NN+1
      IF(NN.NE.NN2)GO TO1710
      WRITE(8,1711)
 1711 FORMAT(5X,'PH(I)',5X,101A1,/,15X,'.')
      GO TO1715
 1710 IF (NN.LE.(M+1))GO TO 710
      SNR=SAND/4.0
      SLR=SILT/4.0
      ROW=1.0+SNR+SLR
      COL=26.0-SNR+SLR
      I=ROW
      J =COL
      P(I,J)=STAR
```

```
      GO TO 701
  300 PAUSE
      DO 230J=1,26
      READ(7,22)(A(I),I=1,51)
   22 FORMAT(51A1)
      WRITE(8,23)(A(I),I=1,51)
   23 FORMAT(40X,51A1)
  230 CONTINUE
      WRITE(8,11)
      DO 9991 I=1,26
      WRITE(8,9992)(P(I,J),J=1,51)
 9992 FORMAT(40X,51A1)
 9991 CONTINUE
      STOPP
      END
```

```
      SUBROUTINE LAGIN3(A1,A2,A3,X1,X2,X3,A,X)
      D=(A-A2)*(A-A3)*X1/((A1-A2)*(A1-A3))
      B=(A-A1)*(A-A3)*X2/((A2-A1)*(A2-A3))
      C=(A-A1)*(A-A2)*X3/((A3-A1)*(A3-A2))
      X=D+B+C
      RETURN
      END

      SUBROUTINE LAGIN2(A1,A2,XI,X2,A,X)
      AA=(A-A1)*(X2-X1)
      B =AA/(A2-A1)
      X =XI+B
      RETURN
      END

      SUBROUTINE CLASS(SAND,SILT,CLAY)
  839 FORMAT(20X,'SEDIMENT TEXTURE')
  820 FORMAT(25X,'SAND',//)
  822 FORMAT(25,'SILT',//)
  824 FORMAT(25X,'CLAY',//)
  826 FORMAT(25X,'SANDY CLAY',//)
  828 FORMAT(25X,'SILTY CLAY',//)
  830 FORMAT(25X,'CLAYEY SILT',//)
  836 FORMAT(25X,'CLAYEY SAND',//)
  838 FORMAT(25X,'SAN SIL CLY',//)
  834 FORMAT(25X,'SILTY SAND',//)
  832 FORMAT(25X,'SANDY SILT',//)
      WRITE (8,839)
      IF(SAND.GE.75.0) GO TO 850
      IF(SILT.GE.[illegible].0) GO TO 851
```

```
      IF(CLAY.GE.75.0) GO TO 852
      IF(SAND.EQ.0)GO TO 810
      GO TO 811
  810 SAND=0.0001
  811 IF(SILT.EQ.0)GO TO 812
      GO TO 813
  812 SILT=0.0001
  813 IF(CLAY.EQ.0)GO TO 814
      GO TO 815
  814 CLAY=0.0001
  815 SANSIL=SAND/SILT
      SILCLY=SILT/CLAY
      IF (SAND.GT.20.0) GO TO 890
      IF(SANSIL.GT.1.0) GO TO 853
      IF(SILCLY.LT.1.0) GO TO 854
      IF(CLYSND.GT.1.0) GO TO 855
      GO TO 853
  890 IF (CLAY.GT.20.0) GO TO 895
      IF (SANSIL.LT.1.0) GO TO 856
      IF(SILCLY.GT.1.0) GO TO 857
      GO TO 858
  895 IF(SILT.GT.20.0) GO TO 859
      IF(CLYSND.GT.1.0)GO TO 853
      GO TO 858
  850 WRITE(8,820)
      GO TO 881
  851 WRITE(8,822)
      GO TO 881
  852 WRITE(8,824)
      GO TO 881
  853 WRITE(8,826)
      GO TO 881
  854 WRITE(8,828)
```

```
      GO TO 881
  855 WRITE(8,830)
      GO TO 881
  856 WRITE (8,832)
      GO TO 881
  857 WRITE(8,834)
      GO TO 881
  858 WRITE(8,836)
      GO TO 881
  859 WRITE(8,838)
  881 RETURN
      END
```

APPENDIX - 3

FORTRAN IV PROGRAM FOR CORRELATION COEFFICIENT

```
      PROGRAM RIJCOMP
      COMMON A (60,60),NUM(60),R(60,60),SUM(60),
      AV(60)
C     SNO=SAMPLE NUMBER
C     N=NO OF COLUMNS
C     M=NO OF ROWS
C FIRST: CORELATION IS FOUND FOR TWO RESPECTIVE
  COLUMNS.
C SECOND: ROWS AND COLUMNS ARE INTERCHANGED AND
  AGAIN CORELATION IS
    1 FORMAT (A5,215)
    2 FORMAT(8F7.3)
    3 FORMAT (5X,12F10.3)
    4 FORMAT (8(2X,IPE14.6))
    5 FORMAT (1H1)
    6 FORMAT (10X,/)
    7 FORMAT(10X,//,10X)
    8 FORMAT (10X,/,10X)
   19 FORMAT(15X,4E15.5)
   22 FORMAT(5X,'ERROR',5X,4E15.5,2(5X,12))
  103 FORMAT(5X,//,85X,'*INDIAN NATIONAL OCEANOGRAPHIC
      DATA CENTRE-AC*')
   70 READ(7,1) SNU,N,M
      IF(N.EQ.0)GO TO 300
      WRITE(8,5)
      WRITE(8,1)SNO,N,M
      MM=0
      READ(7,2)((A(I,J),1=1,N),J=1,M)
```

```
   93 WRITE(8,3)((A(I,J),1=1,N),J=1,M)
      WRITE(8,8)
      WRITE(8,7)
   15 DO 10 1=1,N
      SUM(I)=0
      NUM(I)=0
      DO 11 J=1,M
      IF(A(I,J).EQ.0)GOTO 11
      SUM(I)=SUM(I)+A(I,J)
      NUM(I)=NUM(I)+1
   11 CONTINUE
      IF(NUM(I).EQ.0060 TO 10
      AV(I)=SUM(I)/NUM(I)
   10 CONTINUE
      L=N-1
      WRITE(8,1)SNO,N,M
      11=0
      DO 12 I=I,N
      11=I-1
   14 SUMXY=0
      SUMX=0
      SUMY=0
      11=11+1
      DO 13 J=1,M
      IF(A(I,J).EQ.0)GO TO 13
      IF(A(II,J).EQ.0)GO TO 13
      AI=A(I,J)-AV(I)
      A2=A(II,J)-AV(II)
      AII=A1*A1
      A22=A2*A2
      A12=A1*A2
```

```
      SUMXY=A12+SUMXY
      SUMX=A11+SUMX
      SUMY=A22+SUMY
   13 CONTINUE
      NN=NUM(I)+NUM(II)
      IF(NN.EQ.0) GO TO 21
      RI=SUMXY/NN
      R2=SQRT(SUMX/NN)
      R3=SQRT(SUMY/NN)
      IF((R2.EQ.O).OR.(R3.EQ.0)) GO TO 21
      R(I,II)=RI/(R2*R3)
      GO TO 24
   21 R(I,II)=0.0
      WRITE(8,22)RI,R2,R3,R(I,II),I,11
   24 IF(II-N)14,12,12
   12 CONTINUE
      L=O
      WRITE(8,7)
      DO 52,J=1,N
      L=L+1
      WRITE(8,4)(R(I,J),I=1,L)
      WRITE(8,8)
   52 CONTINUE
      WRITE(8,103)
      IF(MM.EQ.1)GO TO 9999
      MM=MM+1
      DO 95 J=1,M
      DO 95 I=1,N
      R(J,I)=A(I,J)
   95 CONTINUE
      M11=M
      M=N
      N=M11
      DO 96 I=1,N
```

```
      DO 96 J=1,M
      A(I,J)=R(I,J)
   96 CONTINUE
      GO TO 93
      WRITE(8,8)
 9999 GO TO 70
  300 STOP
      END
```

APPENDIX NO. 4

LIST OF SPECIES USED IN CLUSTER ANALYSIS

1. *Ammobaculites persicus*
2. *Textularia conica*
3. *T. foliacea*
4. *Spiroloculina aequa*
5. *S. antillarium*
6. *S. communis*
7. *S. excavata*
8. *S. eximia*
9. *S. indica*
10. *S. planissima*
11. *S. rotunda*
12. *S. tricarinata*
13. *Q.* cf. *Q. bicarinata*
14. *Q. bicornis*
15. *Q. kerimbatica*
16. *Q. laevigata*
17. *Q. lamarkiana*
18. *Q. ludwigi*
19. *Q. oblonga*
20. *Q. parkeri*

21. *Q. phoenica*
22. *Q. polygona*
23. *Q. pseudoreticulata*
24. *Q. rugosa*
25. *Q. sehlumbergeri*
26. *Q. seminulum*
27. *Q. singhi*
28. *Q. undulosa costata*
29. *Q. venusta*
30. *Q.* aff. *Q. viennensis*
31. *Q. vulgaris*
32. *Q. tropicalis*
33. *Q.* Sp. *A*
34. *Q.* Sp. *B*
35. *Triloculina insignis*
36. *T. echinata*
37. *T. qusimi*
38. *T. rotunda*
39. *T. rupertiana*
40. *T. terquimiana*
41. *T. tricarinata*
42. *T. trigonula*
43. *Miliolinella australis*
44. *M. oblonga*
45. *Bolivina limbata*

46. B. striatula

47. B. cf. B. variabilis

48. Bulimina marginata

49. Siphogenerina rephanus

50. Cancris auricula

51. Glabratella sp.

52. Pseudoeponides nakazotoensis

53. Ammonia annectens

54. A. indica

55. A. papillosus

56. A. sobrina

57. A. tepida

58. Asterorotalia dentata

59. A. inflata

60. A. trispinosa

61. Pararotalia calcar

62. P. minuta

63. P. nipponica

64. Elphidium advenum

65. E. craticulatum

66. E. crispum

67. E. discoidale multiloculatum

68. E. indicum

69. E. macellum

70. E. minutum

71. *E. simplex*

72. *Nummulites ammonoides*

73. *Globigerina bulloides*

74. *Globigerinoides ruber*

75. *Eponides repandus*

76. *Poroeponides cribrorepandus*

77. *P. lateralis*

78. *Amphistegina madagascariensis*

79. *A. radiata*

80. *Cibicides lobatulus*

81. *C. refulgens*

82. *C. tenellus*

83. *Caribeanella indica*

84. *Fursenkonia pontoni*

85. *Nonion boueanum*

86. *N. Sp.*

87. *Florilus elongatus*

88. *F. scaphus*

APPENDIX 5

Matrix obtained for Q-mode cluster analysis of beach foraminifera from the west and East Coasts of India.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1		.3														
2	.277	1															
3	.349	.5866	1														
4	.290	.500	.6718	1													
5	.180	.3475	.365	.35	1												
6	.245	.338	.5438	.431	.3777	1											
7	.295	.5479	.6307	.5538	.3859	.5473	1										
8	.179	.250	.2372	.2599	.3429	.3611	.2884	1									
9	.2354	.4057	.4285	.3492	.4545	.3469	.4237	.3421	1								
10	.2115	.3835	.4516	.3950	.5248	.4666	.5	.3421	.511	1							
11	.1957	.29	.3193	.375	.4359	.2608	.3571	.2235	.3953	.5	1						
12	.2222	.1304	.2241	.2453	.25	.2702	.2745	.1652	.1951	.2564	.3224	1					
13	.114	.0734	.100	.1296	.111	.1351	.1538	.08	.0729	.1282	.1613	.4706	1				
14	.18	.3285	.3384	.35	.333	.2917	.333	.2369	.28	.333	.4	.4062	.25	1			
15	.2189	.0895	.0819	.1296	.250	.1351	.111	.1737	.1578	.1282	.1613	.1363	.0526	.1429	1		
16	.2647	.1159	.1475	.1818	.222	.1782	.1833	.1481	.1429	.1732	.1769	.0740	.0435	.1282	.4117	1	
17	.1389	.1029	.1147	.111	.20	.1892	.1481	.1739	.1219	.2308	.2258	.2272	.222	.2353	.375	.2381	1

APPENDIX NO. 6

ALPHABETICAL LIST OF SPECIES (WITH PLATE AND PAGE NUMBER) RECORDED FROM THE WEST COAST OF INDIA

Area	Species	Page No.	Plate/Figure No.
1.	Ammobaculites persicus	27	1/1
2.	Ammonia annectens	135	4/24-25
3.	A. indica	138	5/3
4.	A. papillosus	139	5/1-2
5.	A. sobrina	142	4/22
6.	A. tepida	143	4/23
7.	Amphistegina medagascariensis	194	7/9
8.	A. radiata	197	7/7
9.	Asterorotalia dendata	146	5/4
10.	A. inflata	150	5/5
11.	Bolivina laevigata	112	4/13
12.	B. limbata	113	4/10
13.	B. persiensis	115	4/9
14.	B. striatula	116	4/11
15.	B. Cf. B. variablis	120	4/12
16.	Bulimina marginata	121	4/15
17.	Cancris auricula	129	4/18
18.	Caribeanella indica	208	7/15
19.	Cibicides lobatulus	200	7/10
20.	C. refulgens	204	7/11
21.	C. tenellus	206	7/12
22.	C. Sp.	207	7/14
23.	Cribroelphidum sp.	175	6/12
24.	Elphidium advenum	158	6/1,4
25.	E. craticulatum	162	6/7
26.	E. crispum	164	6/2
27.	E. discoidale multiloculatum	167	6/5
28.	E. indicum	168	6/3

Area	Species	Page No.	Plate/Figure No.
29.	E. macellum	169	6/8
30.	E. minutum	171	6/6
31.	E. simplex	172	6/9
32.	E. Sp.	174	6/10
33.	Eponides repandus	187	7/1
34.	Fissurina laevigata	111	4/8
35.	Florilus elongatus	215	6/15
36.	Florilus scaphus	216	6/13
37.	Fursenkonia pontoni	210	7/5
38.	Glabratella patelliformis	131	4/20
39.	G. Sp.	132	4/19
40.	Globigerina bulloides	181	5/7
41.	Globigerinoides ruber	183	5/8
42.	Globoquadrina dutertrei	185	5/9
43.	Globorotatia cultrata cultrata	179	5/6
44.	Hanzawaia concentrica	218	7/13
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46.	Hyalinea balthica	199	7/6
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48.	L. perlucida	106	4/4
49.	L. semistriata	108	4/6
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51.	Milioline australis	100	4/1
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54.	Nonion boueanum	212	6/16
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56.	Nummulites ammonoides	177	7/8
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59.	P. nipponica	154	5/12
60.	Poroeponides cribrorepandus	189	7/2,3
61.	P. lateralis	191	7/4

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65.	Q. cf. Q. bicarinata	49	2/3
66.	Q. bicornis	50	1/21
67.	Q. Hagni	52	2/8
68.	Q. kerimbatica	54	2/2
69.	Q. laevigata	55	2/14
70.	Q. lamarkiana	57	2/5
71.	Q. ludwigi	60	2/20
72.	Q. mediterranensis	61	3/4
73.	Q. oblonga	62	2/12
74.	Q. parkeri	63	2/13
75.	Q. phoenica	65	3/1
76.	Q. polygona	66	3/2
77.	Q. pseudoreticulata	68	2/1
78.	Q. rugosa	69	2/4
79.	Q. schlumbergeri	70	1/22
80.	Q. seminulum	71	1/18
81.	Q. singhi	73	2/11
82.	Q. undulosa costata	76	2/6
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84.	Q. aff. Q. viennensis	79	2/7
85.	Q. vulgaris	80	1/19
86.	Q. tropacalis	82	1/17
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90.	Spiroloculina aequa	36	1/10
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98.	S. scita	45	1/9
99.	S. tricarinata	47	1/11
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103.	Triloculina insignis	85	3/13
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107.	T. qasimi	91	3/14
108.	T. rotunda	93	3/12
109.	T. rupertiana	94	3/8
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